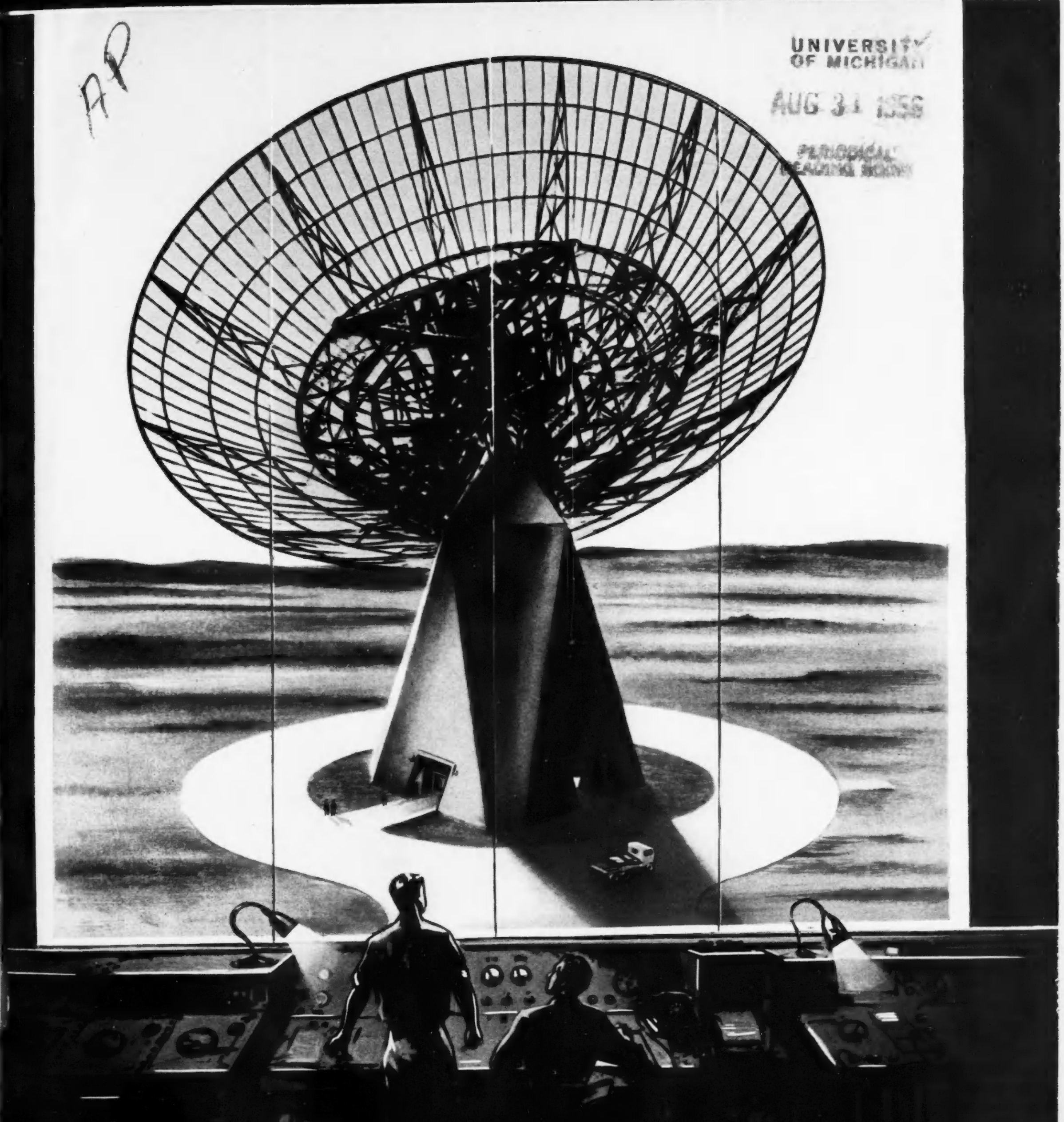
# DISCOVERY

AUGUST 1956 2/6





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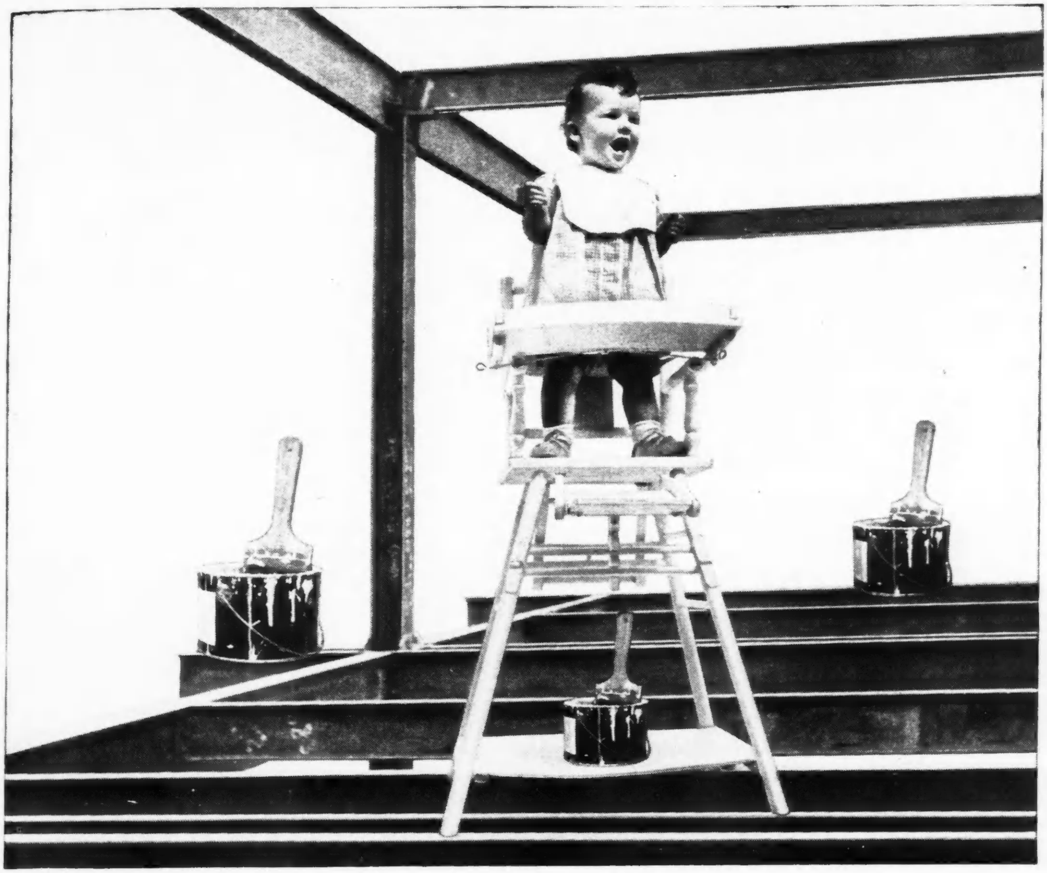

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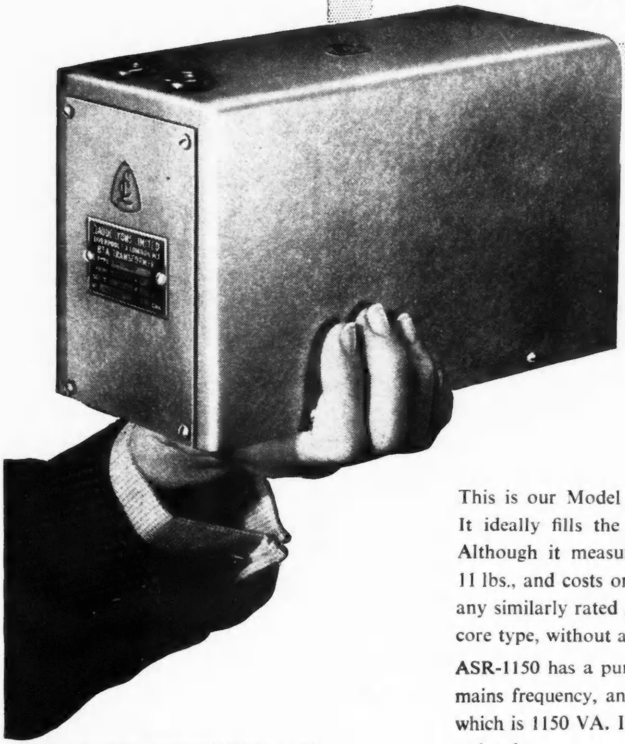

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## CONTENTS



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On our cover this month appears an artist's impression of the new radio telescope to be set up near Sydney, Australia. For fuller details see p. 312.

# THE PROGRESS OF SCIENCE

## ROYAL SOCIETY VISIT TO RUSSIA

Between May 18 and June 2 this year a Royal Society delegation visited the U.S.S.R. as guests of the Academy of Sciences in Moscow. Lord Adrian, O.M., the immediate past-president of the Royal Society, led the delegation which had the support of the Soviet Relations Committee of the British Council. The other members were: Lady Adrian; Dr. H. G. Thornton, Foreign Secretary of the Royal Society (microbiologist); Dr. Mary L. Cartwright, Mistress of Girton College (mathematician); Prof. J. H. Gaddum of the University of Edinburgh (pharmacologist); Prof. J. M. Robertson of the University of Glasgow (organic chemist and x-ray crystallographer); Prof. M. Stacey of the University of Birmingham (organic chemist), and Dr. D. C. Martin, Assistant Secretary of the Royal Society.

The principal purpose of the visit was to increase contacts with Soviet scientists in the respective subject fields of the delegates and to have discussions with Academy representatives on the possibilities of making arrangements for improved co-operation between Soviet and British scientists.

The delegation visited Moscow, Leningrad, and Kiev, the capital city of the Ukraine, and members each visited research institutions and laboratories in which specialised work of interest to them was being done. In this way a considerable range of Soviet research was inspected. All members of the delegation delivered lectures. Everywhere great friendship was shown and a strong desire for international co-operation was very evident. There can be little doubt that, at present, the Soviet scientist is most anxious to meet his opposite numbers in other countries and to become familiar with the research being done outside the U.S.S.R. Whilst the delegation was in Moscow at least five other Fellows of the Royal Society were present including one from Australia and one from Canada. Scientists from many other countries including the U.S.A. were also present.

The wish to know about scientific work in countries outside the Soviet Union is also manifest in two Academy institutions, namely the Academy of Sciences Library, which is in Leningrad, and the Institute of Scientific Information in Moscow. The Academy itself was founded by Peter the Great in 1725 in Leningrad. The Library pre-dated it by a few years and many leading Russian scientists, including Lomonosov, helped in organising it. Its holdings amount to ten million books in Leningrad and three million more at Academy research institutes. It operates a vast exchange programme with foreign countries and last year exchanged nearly 6000 publications with the U.K. alone.

The Institute of Scientific Information was set up in 1953 and its chief task in its short existence is the provision of abstracts in twelve series covering all aspects of natural science. Eleven thousand publications are abstracted annually, 9000 being from outside the U.S.S.R. It also has extensive photocopying facilities, issues full translations of foreign scientific papers on demand, has facilities whereby a translator can sit alongside a scientist to assist in the interpretation of a paper in a foreign language, and has a laboratory studying the mechanical sorting of information; its Director, Prof. Panov, has encouraged the construction of a translating machine. The full-time staff numbers 600 and these are supplemented by a far greater number of part-time abstractors. The Institute photocopies foreign journals for distribution to research laboratories throughout the U.S.S.R. By any standard the achievement of this Institute in three years is most impressive and it is rendering a valuable service to Soviet scientists. The standard of the printing of the abstracts is good and is done by the Academy Press. The time interval between the appearance of the paper and the abstract is about six to eight months.

The Academy headquarters moved from Leningrad to Moscow in 1934 and the Praesidium now occupies a fine building, formerly a royal palace, some little way from the centre of Moscow. Napoleon is reported to have rested for a few hours here at the time of his retreat from Moscow. The Academy, unlike the Royal Society, has responsibilities beyond the natural sciences and has eight divisions as follows: (1) Physics and Mathematics, (2) Chemistry, (3) Biology, (4) Geology and Geography, (5) Technical Sciences, (6) History, (7) Language and Literature, (8) Philosophy, Economics and Law. A member of the Praesidium usually acts as chief of a division; thus, Academician Lavrentiev is in charge of physics and mathematics, Academician Engelhardt of biology, and Academician Dubinin of chemistry. There is a separate Academy for medical sciences.

The Academy of Sciences governs the activity of 126 research institutes, the majority of which are near Moscow or Leningrad, but others are far-flung, for example, in Siberia, Sverdlovsk, and Vladivostok. The U.S.S.R. Academy has advisory powers in relation to thirteen other academies in various regions of the U.S.S.R. Membership of the Academy is in two classes with about 150 full members and 300 corresponding members. Elections take place from time to time when vacancies are declared. Most research in the U.S.S.R. is done in Academy institutes but some academicians are also professors in the universities.

The new University of Moscow being built on the Lenin Hills on the outskirts of Moscow is a very large organisation, there being 22,000 students. The buildings already erected include the headquarters administration (thirty-two storeys high), hostel accommodation for over 6000 students, and many devoted to the natural sciences. These latter are equipped with fine laboratories but Moscow University, exceptional in so many ways, also seemed to be exceptional in conducting research more usually done in research institutes. The teaching staff number over 2500 members, many of whom live in the University precincts. The undergraduate course is five years, the usual age range being from seventeen or eighteen years to twenty-two or twenty-three years, and 57% of the students are taking degrees in natural

science. Moscow is proud of this fine new building for its university which is named after Lomonosov and which recently celebrated its bicentenary.

Scientists in the U.S.S.R. enjoy a high esteem and many privileges. By virtue of their membership of the Academy leading scientists are paid by the State, are provided with cars and country villas and frequently hold positions in research institutes concurrently with professorial chairs. One of the principal impressions was the vast numbers of research workers who are active in Soviet research organisations. One institute doubled its staff from 300 to 600 in the last five years.

The visit of the Royal Society delegation prepared the way for improved international co-operation. With a continuing desire to develop existing friendly relations the not inconsiderable difficulties, principally those of currency, can be overcome to the benefit of scientists in both the U.S.S.R. and the United Kingdom as well as in the international organisations of science.

## HAZARDS OF NUCLEAR AND ALLIED RADIATIONS

Scientists agree that people can be injured permanently by various forms of radiation and that the descendants, even of those showing no obvious injury, may be injured also. This injury is not new for we have always been exposed to a background of radiation, from cosmic rays, rock, air, water, and the potassium in our bodies. During the last half-century, however, we have increased the exposure by activities that can be arranged in three categories: the well established use of x-rays and radioactive paints and research materials; nuclear bomb explosions; and the preliminaries to setting up nuclear power installations. It would be difficult to diminish the background, but the other risks could be avoided. A decision about the scale of these activities and the conditions under which they should continue depends on the balance struck between the advantages we expect from them and the damage we expect to suffer from them. The Medical Research Council was asked to get the advice of an independent expert committee, and its report is now published.*

The report stresses two important points repeatedly. First, the present state of knowledge does not justify many of the positive assertions that are made about safe levels of exposure. We know, for example, that flies and mice are affected differently by certain intensities of x-raying: people in many ways resemble mice rather than flies, but it is pure assumption that this resemblance extends to x-ray sensitivity. We also know how much radium people have eaten without apparent harm; this is an insecure footing for the step to the permissible dose of radio-strontium. The committee is well aware of these things and of the need for getting research organised. It may be quoted: "Our present knowledge does not justify us in naming any specific figure as a limit for the average dose of radiation which might be received by the population as a whole. It is highly desirable that such a figure should be named as soon as possible; and we understand that the International Commission on Radiological Protection has this matter under consideration. In the meantime, we feel bound to state our opinion that it is unlikely that any authoritative recommendation will name a figure for permissible radiation dose to the whole population, additional to that received from the natural background, which is more than twice that of the general value for natural background radiation. The recommended value may, indeed, be appreciably lower than this."

Secondly, the report disposes conclusively of the idea that good could come from an increased exposure to radiation. Evolution can only proceed if there is a supply of mutations for selection to work on; this leads some ill-instructed people to think it would go faster with more mutations. We are far from perfect, but this is not the way forward. J. B. S. Haldane put the matter vividly (I quote from memory) at a recent Science for Peace Conference, "My watch is sometimes a little erratic. It is conceivable, that if I poke my finger into it, it will go better; but it is much more probable that it will stop altogether." This, in essence, is the committee's view. It also recognises that any increase in non-hereditary disability is likewise to be deplored. This is particularly pleasing because Sir Ernest Rock Carling, a member of the committee, caused world-wide indignation by the cynical sophistry of his remark at Geneva last year that an increase in disability would be useful in solving the world food shortage.

The report tries to assess the amount of harm that is being done now, and concludes tentatively that we have increased the background by one-quarter and so increased the mutation rate by 1%. This does not sound alarming, but a 1% increase in mutation rate means about twenty new cases of hereditary mental defect, and about three times as many other hereditary defects, in each generation in Britain. Other authorities have put the number much higher.

The biggest single source of this extra radiation is x-ray diagnosis. Its value is obvious but the committee wisely recommends some reconsideration of the scale on which it is used, particularly with people under thirty and on sites that may involve exposure of testes or ovaries. The casual use of x-rays for such things as shoe-fitting is roundly condemned.

Nuclear explosions present fewer difficulties. Most of the world's inhabitants would condemn them, even if they did not release radioactivity, because of the international suspicion they cause. They are so expensive that they have always seemed folly; it is clear now that they are criminal as well. No one has a right to drop radioactive fallout on his neighbours, and it seems near to piracy to make large areas of the ocean unnavigable because of their radioactivity. The report, naturally, does not put it in quite this way. It simply points out that the radio-strontium that has already been blown into the stratosphere by bombs will ultimately come down. It is being deposited in peoples' bones all over the world, and the level in the bones of children is already alarming. The danger point will be reached in

* "The Hazards to Man of Nuclear and Allied Radiation". H.M.S.O. Cmd. No. 9780, price 5*s*. 6*d*.

a few years if the present rate of test explosions is maintained. Radioactive iodine and caesium are also accumulating, but seem to be a less immediate danger.

With sense and goodwill, bomb tests could be abolished. Nuclear power, on the other hand, will be with us to an increasing extent. The report is encouraging about the danger of running power stations and claims that it need be no greater than that incurred in making power by conventional means. It goes on to state that "society weighed" these risks against the advantages expected. Society was hardly as rational as this; it fell into and over the risks. This will happen again unless we are careful and realise that we are at the beginning of something radically new: something that is potentially valuable no doubt, but also something that is potentially a menace. It is this that makes the naïve opportunism of our nuclear engineers so exasperating. Their actions in trying to throw radioactive rubbish down a mine in the Forest of Dean or to build a small power station on the Thames estuary resemble those of a man who tips out his tea-leaves on the front doorstep and then begins to think about the contents of the dustbin. We laugh at the old gentleman with side-whiskers carrying a red flag in front of the early steam trains, but we should remember that it was this Victorian recognition that steam trains were a new phenomenon that restricted them to safe enclosures fenced off from other traffic. A later generation did not think so clearly about motor cars, and tried to graft them on to an existing system; present-day road casualties show the consequence. We should err on the side of caution in siting nuclear power stations and dealing with their products.

The report recognises that power-station workers will be at extra risk and argues wisely that this is a further reason for protecting the rest of the community from all avoidable radiation. It is a pity that in this section little attention is paid to the hazards of mining uranium ore. The old results at Joachimsthal, where lung cancer accounted for half the miners' deaths, are quoted. The average latent period is about seventeen years, so we would not yet expect similar rates from Rum Jungle while the affairs of Katanga are kept secret.

Sir Harold Himsworth is to be congratulated on having shepherded his distinguished and probably idiosyncratic flock to a unanimous conclusion. Most of the report is clear and readable, though a few opaque passages suggest the remains of patched-up disagreement. The writers are so distinguished that the reader cannot be absolutely certain that not one of them knows what the word "anticipate" means; this makes a few other passages ambiguous. Almost all the terms used are adequately defined, and the Stationery Office has produced the good value for money to which we are accustomed.

## REFLEX AND INSTINCT

Some experiments which promise to throw fresh light on the old problem of instinct in animals were demonstrated at the Royal Society Conversazione in May by Dr. J. S. Kennedy and Mr. C. O. Booth. Their particular problem was to discover what governed the waxing and waning of the two alternative patterns of instinctive behaviour—feeding on a plant and flying—in the winged form of the humble green-fly or aphid. It was known that the young adult aphid would take wing, refusing to stop and feed or deposit its young even on the best of host-plants; but that the longer it flew the more ready to settle down it became. It was also known that this change of "mood" was not simply due to physical exhaustion because it could be brought about by very little flight indeed. Such an apparently spontaneous lowering of the threshold for an instinctive act during a preceding phase of locomotory activity had been observed before in other animals, and taken as evidence that instincts were different in principle from reflexes. K. Lorenz inferred that an instinctive act, unlike a reflex, required a prior accumulation of appropriate nervous energy, as an endogenous process not due to external stimulation. The building up of this "drive" first set off the locomotory ("appetitive") activity, then discharged the instinctive act proper when the right external "releaser" was encountered by the animal. This view seemed to fit the facts so much better than the previous conception of instincts as chains of reflex responses to external stimuli, that it has given a great impetus to the study of instinct since the war. The

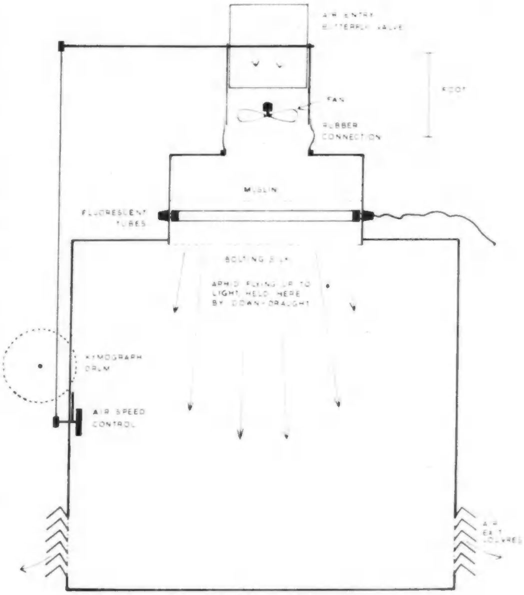


FIG. 1. Cross-sectional diagram of the apparatus for keeping an aphid in free flight. A fan blows air downwards through a battery of lights and a bolting silk screen into the large black-walled chamber in which the aphid is released. The butterfly valve in the air intake is operated by hand from inside the chamber so as to maintain just sufficient down-draught to prevent the insect reaching the screen above. The cable to the butterfly valve also operates a recording pen (not shown) writing on the kymograph drum.

only trouble was that it fixed a gulf between behaviour and physiology, and there has been much discussion as to how this gulf could be bridged again.

The first problem with the aphids was the technical one of getting them to fly freely, and alight naturally on a plant, in the laboratory, for it was soon found that handling them distorted their subsequent responses. This ruled out the use of any of the techniques of tethered flight that have been developed by insect physiologists. The new technique which was demonstrated keeps the insect in free flight by balancing its strong attraction to light against an air-jet, in a sort of air treadmill (Fig. 1). The insect's "lift" often changes while it flies so that it can only be kept in the air by compensatory adjustments of the air speed by the operator. But by coupling the air speed control mechanism to a recording pen, a continuous record is obtained of the strength of the insect's upward flight response to the light, which gradually fatigues and ceases after anything from 30 minutes to 4 hours. The same pen conveniently serves to record the strength of the insect's response to the plant on which it is allowed to alight, of its own accord, after a predetermined period of flight.

The quantitative interaction between these two opposite types of response could now be studied. As

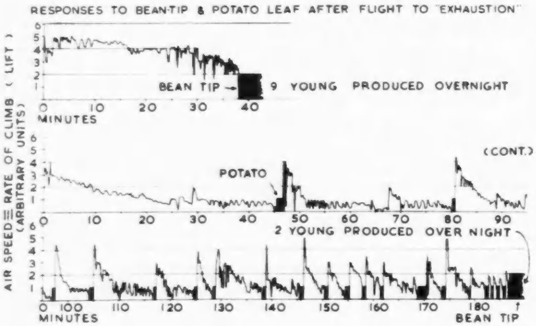


FIG. 2. Sample records obtained in the aphid flight chamber. Irregular line—aphid in flight; solid blocks—aphid on plant. *Above*: a Bean Aphid, which before flight will not settle down to feed even on a suitable plant, is flown until it appears to be exhausted and then allowed to land on a suitable plant where it quickly settles down to feed and bears nine young in the next 24 hours. Showing how flight predisposes the insect to respond to the host-plant. *Below*: a similar aphid also flown to apparent exhaustion but then alighted on an unsuitable plant (potato) where it inserts its beak but soon takes off again, its flight vigour fully restored; the whole sequence is repeated many times, with the lift at several take-offs exceeding that at the original take-off; when finally alighted on a suitable plant the aphid settles there but bears only two young in the next 24 hours. Showing how the feeding-parturition response to a host-plant, although strongly "primed" by a preceding flight, can be inhibited again by contact with an unsuitable plant and then has a reciprocal "priming" effect on flight. Such inhibition of the host responses, when repeated, becomes lasting (as shown by the reduced parturition rate) even after the maximum possible "priming" of the host responses by flight to complete exhaustion.

the results accumulated it became progressively clearer that there was after all nothing here different in principle from reflex action. The behaviour of the whole insect followed with surprising faithfulness the laws established years ago by Sherrington for the reflex activity of the mammalian spinal cord. Most relevant to the aphid with its two alternative sets of behaviour patterns was the law of "reciprocal innervation" of antagonistic spinal reflexes, according to which excitation of either inhibits the other. For inhibition of a spinal reflex increases its excitability, so that when the inhibition is removed the reflex "rebounds" with greater strength than it showed before, sometimes even without any further stimulus. The two types of response in the aphid showed the same kind of reciprocity. Not only did a prior flight strengthen the aphid's response to a host plant, but also, reciprocally, a prior host response strengthened the flight response (Fig. 2). This "priming" of one reflex by a preceding antagonistic one Sherrington called "successive induction", and he found that it played a part in generating oscillations between two opposite movements (for example alternate flexion and extension of a leg) even when the stimulus was not oscillatory but constant. That kind of effect, too, is observed in the higher-order co-ordinations of the aphid. Indeed the two opposite behaviour patterns of the aphid interact in every respect like antagonistic reflexes in the spinal cord.

This means that the build-up of an instinctive "drive", like that for feeding and parturition in the aphid, can no longer be considered independent of external stimulation. It is due to external stimulation, here of the antagonistic flight reflexes, which inhibit the feeding-parturition reflexes temporarily so that they later "rebound". The build-up of the "drive" appears to be endogenous only if the *active* nature of the nervous process called inhibition is overlooked, as so often happens. Likewise, it is putting the cart before the horse to regard the aphid's flight which brings it to a new host-plant, as "appetitive" or host-seeking behaviour. It is not the aphid's appetite for a new host-plant that makes it fly, but flying that creates the appetite—which seems reasonable enough! The needed bridge between behaviour and physiology seems to be under construction.

## GIANT RADIO TELESCOPE FOR AUSTRALIA

The settlement of Australia was the direct result of an astronomical mission. The main object of Captain Cook's voyage of 1769–70, which led to the first settlement, was to take a party to Tahiti to observe a transit of the planet Venus across the Sun.

Now Australia is planning a giant radio telescope (see cover), and observations through it should advance the new science of radio astronomy, which had its origins in two accidental discoveries. In 1932 radio-frequency radiation from the Milky Way was observed in the United States during tests of a transatlantic radio-communication system; and during the war radar sets in England occasionally received high-level radiation from sunspots.

In 1952 the Union Radio Scientifique Internationale held its Tenth General Assembly in Sydney, and Sir Edward Appleton, President of the Union, strongly urged the erection of a giant radio telescope in Australia. On December 17, 1955, Mr. R. G. Casey, Minister-in-Charge of CSIRO, announced that the Rockefeller Foundation would grant CSIRO up to $250,000 towards construction of such a telescope. The Australian Government has undertaken to provide half the cost of the telescope on condition that non-government sources provide the other half. The Carnegie Corporation of New York have promised $250,000, and, with contributions from Australian donors, about £A480,000 is in sight. The total cost will probably be between £A500,000 and £A600,000. Messrs. Freeman, Fox and Partners, the British designers of Sydney Harbour Bridge, have undertaken a design study of the project.

It was during the 1939–45 war that Australian work on radio-astronomy began at the CSIRO Radiophysics Laboratory, whose first achievement was to establish that the sudden "bursts" of radiation observed to emanate from the sun originated in the vicinity of sunspots. Soon afterwards it was demonstrated that radio sources of small angular size existed in the sky. A radio source in the constellation Taurus was shown to be identical with the Crab Nebula, a mass of hot gas which is the expanding remnant of a stellar explosion seen by Chinese astronomers 1000 years ago. Another important finding, established simultaneously in Australia and England, was that the most intense radio stars have a finite angular size and may be considered as having the characters of "radio nebulae". Contributions have been made to general astronomical knowledge of our galaxy and several others, including the Magellanic Clouds; and radio echoes from the Moon have been studied.

The CSIRO Radiophysics Laboratory has developed many ingenious aerials now used all over the world; and it has also constructed a solar radio spectroscope which enables observation of a solar "burst" over a wide range of wavelengths.

The new giant radio telescope will probably be used for the following four types of observation: (1) surveys at different frequencies of both sources and background, to provide more information on the statistics of the distribution of sources, spectra of both types of radiation, and the fine structure of the background; (2) spectra of particular sources and regions of the sky over a continuous frequency range; (3) measurements of angular size of sources, which is important for identification and classification into galactic and extra-galactic objects; (4) observations of astronomical objects of interest, such as external galaxies, hill regions, planetary nebulae, and globular clusters, where radio data often yield valuable information on the physical state of the systems.

The radio telescope which is to be set up at Manchester University will be a complement to the Australian one, the former studying the northern, and the latter the southern skies. And in its turn the Australian radio telescope will complement the 74-inch reflecting telescope at Mt. Stromlo, Canberra. So far knowledge of the southern sky lags behind knowledge of the northern, and these two Australian telescopes should very soon repair the discrepancy.

## ANTIBODY PRODUCTION BY NUCLEOPROTEIN

Antibody production provides a case of protein synthesis in the living animal which can be quantitatively measured and experimentally controlled. Although it has been the subject of intensive study by biologists and biochemists, little is yet known of the control of antibody production at the cellular level: of the factors which decide whether a potentially antibody-producing cell manufactures antibody or "normal" globulin, or how the production of a specific antibody can continue for months or years without continued stimulation. A key role for nucleoprotein in this control has now been claimed by two workers in the Czechoslovak Academy of Science, Prague.

Reporting this recently, Šterzl and Hrubešová* have first shown that *Salmonella paratyphi*, a bacterial antigen which effectively elicits antibody production in adult rabbits, is unable to do so in rabbits less than a week old. The young rabbits are evidently immature immunologically. But nucleoprotein was then extracted by saline from the spleen of immunised adults and injected into the young; this injection led to the rapid appearance of antibody in their blood. Since antibody cannot be detected in the nucleoprotein extracts, the antibody detectable in the blood must indicate that antibody synthesis took place in the young host. An explanation is tentatively given that nucleoproteins are concerned with antibody production in the spleen cells of immunised adults, and that after transfer they enter the host cells where they initiate further production of antibody.

These Czech experiments may provide an important link in the chain of evidence identifying nucleoproteins with the mechanisms controlling protein synthesis. A controlling role for nucleoproteins in the cells has long been postulated: they form an essential part of the genetic material, for example, and are found to increase in concentration immediately before and during protein synthesis. What is novel in the present experiments is the possibility that this control mechanism can be extracted, fractionated, and transmitted from one tissue cell to another. The control mechanism of a tissue cell may be capable of analysis by these means, which have been applied before only to micro-organisms.

Immunologists in Britain and America have also been aware of these possibilities, so that Šterzl and Hrubešová's work must be interpreted in the light of parallel work on slightly different experimental systems. Up to now specific antibody production has not been transmissible from cell to cell. The Czech workers do in fact interpret their findings with caution. Confirmation and further elucidation of their work will be eagerly awaited.

* "The transfer of antibody formation by means of nucleoprotein fractions to non-immunised recipients", *Fol. Biologica (Praha)*, 1956, vol. 2, p. 21.

# BRAIN CHEMISTRY AND BEHAVIOUR

**R. W. RUSSELL**

*Professor of Psychology, University College, London*

*Prof. Russell believes that the work recorded in the following article, and undertaken in collaboration with the Toxicology Unit of the Medical Research Council, may prove to be of the utmost importance in the treatment of certain types of psychological disorder. Experimental work with the drugs described by Prof. Russell is rewarding because behaviour is very sensitive to biochemical changes, and changes in behaviour are therefore frequently visible before organic symptoms appear. The usual procedure when searching for physiological bases of behaviour has been to interfere with the structure of the organism, the disadvantage being that structural changes are irreversible. Interference with the dynamics, on the other hand, is a reversible and therefore less drastic process which offers possibilities for work on human beings as well as on experimental animals.*

*Prof. Russell, an American, began his career studying physiology, and his interest in psychology began when he worked under the well-known Behaviourist, Walter S. Hunter, at Clark College in the United States. He first came to England in 1942 as Research Projects Officer to the U.S. Air Force. In 1945 he was Staff Liaison Officer with the Air Ministry, and in 1949 he was appointed Fulbright Advanced Research Scholar, and Director of the Animal Behaviour Research Laboratory at the Institute of Psychiatry, London University. Since 1950 he has been Professor and Head of the Department of Psychology at University College, London, and also Honorary Director of the Medical Research Council for Research in Industrial Psychology. He has now been granted a year's leave of absence to return to his home country, where he will act as Executive Secretary to the American Psychological Association. It is clear in conversation that he has a real fondness for Great Britain and for the department in which he has been doing so much valuable work, and he hopes to keep in touch with the researches while he is away. In his absence, his students and colleagues will surely miss his simple, humorous, and sympathetic approach.*

During the normal course of our lives we are seldom aware of the host of biochemical events which are essential to the adequate functioning of our nervous system. It is only when something interferes with these events that we give them any special attention, that we begin to appreciate how important they are to our mental, as well as our physical, health. When these events are upset it is usually the result of some disease or injury, but occasionally the relations between brain chemistry and behaviour are called to our attention in more dramatic ways.

## NERVOUS SYSTEM POISONS

During the 1939–45 war we heard occasional rumours of the existence of so-called "nerve gases". In fact these were more than just rumours. Research chemists had synthesised substances which act as nervous system poisons. When a laboratory animal is exposed to such drugs effects first appear as changes in its behaviour. Intense scratching and washing are followed by changes in posture, by quivering and tremor of the legs, by difficulties in breathing, and by convulsive attacks. Eventually stupor develops and, if the dose is sufficient, the animal fails to recover. The signs are those we associate with failure of the nervous system to function properly.

In recent years certain of these drugs have been used in the preparation of insecticides. They are referred to as "systemic" insecticides because they are taken up by the cells of plants to which they are applied and are in turn ingested by insects feeding on the plants. Although serving these purposes very efficiently, the presence of these drugs in plant tissues may be hazardous when, at a later time, the plants are eaten by man.

The action of these drugs has made them of much wider interest than in war and agriculture. They are being used in the study of nerve physiology and of the relations between the activity of the nervous system and behaviour. They are being tried in the treatment of certain psychiatric illnesses.

They exert their action by interfering with the activities of cell enzymes, by producing "biochemical lesions". Normal functioning of the nervous system depends upon an entire chain of biochemical events. Among these events is the synthesis of acetylcholine (ACh), a substance essential to the transmission of nerve impulses. During activity ACh is released at the junctions between motor nerves and muscle fibres, and it can be demonstrated experimentally that minute amounts of ACh in these regions evoke muscle twitches. There is evidence that the transmission of impulses in other parts of the nervous system, including the brain, is also maintained by the action of ACh. This vital chemical substance plays its role as long as it is present in small quantities; beyond certain concentrations its effects are to paralyse nerve transmission. This means that, during the normal functioning of nerves, ACh must not accumulate; it must be inactivated very rapidly after its release. Existing at the proper places and in adequate amounts is an enzyme or biocatalyst, cholinesterase (ChE), which serves this important function. This enzyme hydrolyses ACh, its action taking place almost instantaneously.

The action of the drugs referred to earlier is to decrease the activity of ChE and because of this action they are called "anticholinesterases". By lowering the level of activity of ChE they allow the accumulation of ACh; they interfere with the inactivation of ACh after its release. Changes in the general level of neural activity accompany changes in ACh content and, since behaviour is dependent upon neural activity, we would expect to find these fluctuations in brain chemistry to be reflected in behaviour.

## NERVOUS SYSTEM POISONS AND BEHAVIOUR

The extreme action of these anticholinesterases is to produce convulsions, stupor, and, eventually, death. But these extremes are reached only when the activity of brain ChE has been reduced very drastically indeed. Animals in which this activity has been inhibited by 85% still appear, on superficial examination, to behave quite normally; and no pathological changes in the tissues can be discovered. It appears that there is a vast margin of safety in the way ChE acts to maintain the normal physiological functions of the nervous system.

But it is, in fact, often possible to note changes in behaviour long before any gross pathological conditions appear. These changes are generally very subtle and can only be discovered by precise measurement. They may be exceedingly important just because they are subtle and because for a long time they pass unnoticed. The measurement of behaviour, therefore, has become a major technical issue in research of the kind we are discussing, and it is in regard to this issue that the psychologist is qualified to make his major contribution. One example may help to illustrate the basic characteristics of such measurement, but a whole host of other well-standardised procedures could be described. It is generally agreed that, to survive, living organisms must be able to adjust themselves to the changing conditions of their environment. This means that they must learn to respond to the important characteristics of that environment—where to get food and water, how to escape from predators, how to communicate with other members of their own species. This ability to learn can be studied in the laboratory under carefully controlled conditions. A standard procedure for use with infrahuman animals has employed a maze through which the animal must run to get its food. Learning can be measured in terms of the number of correct responses or errors, or in terms of the time taken to reach the goal. Careful comparisons of the performance of drugged and normal animals in terms of these units may then reveal differences which would not be apparent from gross observations of behaviour. Standardised techniques of this kind are available for measuring many other forms of behaviour ranging from simple sensory discrimination to complex reasoning and problem solving. Much research in the past has emphasised precision in the control and measurement of biochemical events, but has reported behaviour only in terms of broad categories such as "stupor", "slowing of reactions", "changes in mood", etc. What we really want to know is: *how* stuporous, *how* slow, what *degree* of change. It is only when these broad categories are defined more specifically in terms of measurable behaviour patterns that precise relations between brain chemistry and behaviour are likely to be discovered.

In our own laboratory during the past few years we have been interested in searching for these more subtle relations. In one series of experiments we introduced very mild doses of an anticholinesterase into the animal's diet—ten parts of drug to one million parts of diet. No severe symptoms appeared; we could see no differences in the behaviour of drugged and control animals by watching them in their cages. However, when we studied their behaviour quantitatively we found certain significant differences. The drugged animals tended to make more errors in learning a new habit; they were less efficient in solving problems; they were slower in eliminating inadequate responses; and they were less effective in adjusting to stresses imposed by the environment. Analysis of brain tissue showed that these differences in behaviour were associated with differences in the ChE activity of the brain. Further experiments indicated that, in general, the more severe the inhibition of ChE activity in the brain, the more pronounced were the effects on behaviour.

## BIOCHEMICAL CHANGES AT SPECIFIC LOCALITIES IN THE BRAIN

These experiments involved changes in ChE activity of the brain as a whole. Behaviour may also be altered by changing the ACh content in specific localities in the

brain. For example, applying ACh in suitable concentrations to the motor areas on one side of the cerebral cortex may change the handedness of an animal. In ambidextrous subjects it may produce a striking increase in the use of the hand controlled by the side of the brain treated. In such instances altering the brain chemistry locally produces significant changes in habits which have belonged to the animal's repertoire of behaviour for a very long time. Injecting an anticholinesterase in the common carotid artery results in the appearance of a form of abnormal behaviour, called "forced circling" in which the animal continues to circle in one direction and occasionally spins on its hind legs. In this instance the anticholinesterase is carried to parts of the brain irrigated by branches of the artery and ACh accumulates in those parts in larger concentrations than normal. The result is an appearance of an unusual form of response which dominates the animal's behaviour as long as the local biochemical events are affected.

Recently techniques have been developed by which it is possible to inject ACh and various anticholinesterases directly into the ventricles of the brain through a metal tube or cannula screwed into the skull and kept permanently in position. The evidence is that such injections affect mainly, if not entirely, certain specific areas in the grey matter of the brain. Effects of ACh and anticholinesterases given in this way are very similar, as we would expect, since in both cases the local ACh concentration is above normal. Depending upon their concentrations they produce severe itching, changes in locomotion, tremor, and eventually a deep "catatonic" stupor during which unusual postures are retained for many seconds or even minutes.

Our results indicate that the most striking effects of anticholinesterases in mild doses are upon behaviour patterns included among the "higher mental processes" —learning, memory, and problem solving. Other central nervous system poisons with different actions on the chemistry of the brain affect different aspects of behaviour. Recently we have been studying the effects of DDT, which, in sufficient concentration, produces tremors, convulsive seizures, respiratory failure, and eventually death. In mild doses this drug affects an animal's gait and its locomotion, but not the more complex aspects of behaviour affected by the anticholinesterases. Such differential effects are encouraging for they suggest that eventually it may be possible to describe the particular aspects of brain chemistry that are fundamental to particular types of behaviour.

## CHEMISTRY AND BEHAVIOUR OF NORMAL SUBJECTS

The general research approach in the studies mentioned so far has been to alter the normal activity of the brain and to observe concomitant changes in behaviour —to interfere with the plumbing, as an irreverent colleague has put it. Might it not be that animals who normally show differences in behaviour also differ in their brain chemistry.

Recently research workers at the University of California in America have reported just such relations. Behaviour was studied in a maze which allowed the animals to select either a visual or a spatial method of getting through. After sufficient trials to establish which of the two methods each animal consistently selected, the concentrations of ChE in the visual, somesthetic, and motor areas of the brain were determined. The animals which worked on a visual solution showed a progressive increase in ChE activity from the visual, through the somesthetic, to the motor area, while those selecting spatial cues had no such consistent pattern. The animals which worked on a spatial method had significantly higher ChE activity than the "visual" in both sensory areas, but not in the motor area. The research workers suggest that high ChE activity in the sensory areas makes for a more generally adaptive, perhaps we might say more "intelligent", animal.

Since these biochemical events take place within certain structures of the brain, we might expect that physical damage to these structures would produce changes in behaviour similar to those produced by interfering with the biochemical events. In fact structural damage to the cerebellum is known to produce irregularities in movements similar to those produced in our animals fed with DDT. The changes in problem-solving behaviour associated in our studies with inhibited ChE activity are similar to changes in the same behaviour following damage to the cerebral cortex of the brain. Other research workers have reported that biochemical lesions duplicate behaviour patterns produced by removal of brain tissue or by electrical stimulation of specific areas of the brain. The relations of structure and function in the brain to behaviour are, as we would predict, very close.

In the modern scientific psychology "mind" is equated with behaviour. Studies of the kind I have been discussing constitute a relatively new attack on problems concerning the relations between behaviour and the functioning of the brain. This attack calls for the combined skills of the biochemist, the pharmacologist, the physiologist, and the psychologist. Results already suggest that knowledge in all these disciplines may benefit. From such knowledge are likely to come practical applications of considerable importance, for example, methods of treating those who suffer from certain forms of mental illness.

## "EXPERIMENTAL PSYCHOSES"

May it not be that abnormal behaviour patterns in man—for instance, the neuroses and the psychoses—are also associated with abnormalities in brain chemistry?

On the same day not long ago I saw two "patients" both suffering from behaviour disorders characterised by the same general symptoms. One was a young woman in a mental hospital; the other was a cat in a medical research laboratory. The young woman's disorder was of unknown origin, but the cat's abnormality had been produced experimentally by a drug injected directly into the ventricles of its brain. Recently the use of these drugs as tools for research has led to the

emergence of an "experimental psychiatry" and has even opened what Aldous Huxley calls "the Doors of Perception" to imaginative laymen.

Some of this research has employed a procedure commonly referred to as the "self-experiment". The research worker himself takes the drug and later records its effect in detail. Mescaline, opium, hashish, ether, nitrous oxide, cocaine, and related chemical substances have been used and many records of their effects describe symptoms comparable to those of the psychoses. Self-experiments on mescaline, sometimes referred to as "the drug of the visionary", were first reported about 1896. From this and many more recent reports certain special characteristics of the intoxication stand out clearly. Most striking perhaps is the predominance of visual experiences. In the words of one research worker:

> With closed eyes visions of moving, constantly changing patterns appeared and attracted the whole attention: Oriental tapestry, mosaic-like wall papers, kaleidoscopic coloured geometric patterns, lines in brilliant luminescent colours or in black and white . . . the colours were sometimes dazzling and gaudy . . . and shortly afterwards there were tender pastel shades. The colours of red objects appeared more pure, more clean, untarnished by dirt, then a moment later everything seemed vague, remote, veiled, not quite real.

Perception of the environment is disturbed. Time appears to be changed, to become fragmentary and discontinuous. Consciousness varies from a rather detached self-evaluation to extreme drowsiness. Certain experiences belonging to one sense become attached to another; one subject reported that sounds in the room were accompanied by hallucinatory dots of colour in the air. Sensory illusions, particularly visual and tactile, appear. Frequently, but not always, these experiences are described as having been very pleasant.

The effects of other drugs are often reported as overlapping those of mescaline, though they differ in certain predominant features. For example, hashish produces special forms of dissociation of thought and excessively vigorous responses or restlessness. Auditory hallucinations, accompanied by fear and sometimes terror, characterise cocaine intoxication.

During the past few years new chemicals and chemical compounds have been discovered, which produce symptoms in normal human subjects analogous to those experienced by psychotic patients. The effects are often strikingly similar despite differences in their chemical structures. One of these new drugs, lysergic acid (LSD), has received particular attention. As with mescaline it produces serious disorganisations of normal behaviour, including disturbances of perception and thinking, changes in mood, and the appearance of hallucinations and delusions. Given to schizophrenic patients it produces a marked aggravation of their abnormal symptoms. Given to normal subjects, it produces mild schizophrenic symptoms.

Other drugs produce different symptoms. Injection of animals with the drug bulbocaprine in suitable doses induces a condition referred to as "experimental catatonia". This condition frequently has a sudden onset following a latent period of thirty seconds to three minutes after injection of the drug. The animal develops an extremely stuporous state; it can be put in abnormal postures which are retained for many seconds or even minutes. It is extremely unresponsive to changes in its environment. Recovery is gradual, but during the effective period of the drug the animal exhibits many of the symptoms of human patients suffering from the mental illness called catatonic schizophrenia. Experimental catatonia may also be produced by the presence of various anticholinesterase drugs and of ACh in the ventricles of the brain. In certain types of mental patients injection of an anticholinesterase may aggravate the condition and cause a reappearance of the symptoms which characterised the onset of the illness.

By such experimental observations the fact has been established that symptoms of abnormal behaviour may be induced by drugs which temporarily alter normal biochemical events in the brain. This bit of general information is interesting and valuable, but, for a science of behaviour, it is only a beginning. What must follow is a much fuller understanding of the relations between particular biochemical events in the brain and particular aspects of behaviour. We have seen that a number of substances with quite different chemical structures may induce very similar behaviour symptoms. Does this mean that their actions on the central nervous system are the same despite their structural differences? Or does it mean that a variety of different biochemical changes are reflected in similar alterations of behaviour? Some answers to these kinds of questions are already suggested in the research literature. Stupor and catatonia appear as characteristic features of behaviour following the injection of a variety of different anticholinesterase drugs into the ventricles of the brain. The common physiological action of these drugs is to inactivate the enzyme ChE, and thus to allow the accumulation of ACh in the brain tissue affected. Intraventricular injection of ACh itself produces similar symptoms. The evidence also strongly suggests that this common feature in the biochemical events affects the same particular region in the grey matter of the brain. Drugs producing other primary behaviour symptoms, such as hallucinations, also differ in their chemical structures, yet recent research has suggested that they, too, accumulate in a particular region of the central nervous system, where they may have their primary action. Although the picture is still a very hazy one, it does suggest the value of searching for relations between particular forms of behaviour and particular biochemical events in particular regions of the central nervous system.

If from such research we are to draw conclusions regarding psychiatric illnesses we must be confident that the experimentally produced symptoms are the same in nature and origin as the clinically observed symptoms. There is ample evidence to show that the experimental and spontaneously occurring symptoms have features

in common. But there are also differences which, at the present stage of our knowledge, makes it risky to draw analogies between the biochemical events underlying the two.

Another basic issue centres on the question whether drugs of the kind we have been discussing "create" new behaviour patterns or merely release patterns which are already present. There is as yet no adequate answer to this question. Our own research suggests that animals with reduced brain ChE activity show certain signs of reacting more severely to environmental stresses than do control animals. The effect of the drug has been to make the animal more susceptible to disorganisation of behaviour patterns which already exist. This evidence is very fragmentary and needs to be followed up systematically.

## CHEMOTHERAPY

The possibility always exists that, when we know the relations between brain chemistry and behaviour, we may be able to provide chemical means of altering at least certain types of behaviour disorders. Brief descriptions of two very recent clinical studies will illustrate how this possibility is being investigated.

The first was designed to study the value of ACh as a therapeutic agent. Two hundred and eleven patients with anxiety symptoms and belonging to a wide variety of diagnostic categories were treated. The usual course of treatment covered a period of six to ten weeks and included thirty injections. Not all categories of patients responded to the treatment, but in one group, referred to as "obsessional", about 70% showed improvement. In these patients the obsession took the form of a recurrent thought of an unpleasant nature or a particular phobia associated with considerable tension. Patients suffering from the more classical obsessional neurosis of long duration and accompanied by compulsive behaviour received but little benefit from the treatment. These results indicate that a very particular set of behaviour symptoms was affected by altering biochemical events.

The second study involved the treatment of patients suffering from chronic catatonic stupor, the condition which, as I mentioned earlier, can be simulated by injections of an anticholinesterase or ACh into the ventricles of the brain. These patients were given intraventricular injections of several drugs, but the one to which I would like to give special attention is ChE, which had the most marked effects. These effects were noticeable within the first minute following injection, and within one to three hours patients, who before injection had been completely unresponsive to stimulation, began to react to instructions and to reply to simple questions. Improvement continued in many cases until the patient was able to take care of his own general needs and persisted for varying periods ranging from four weeks to a number of months. Only two of the fifteen patients treated with ChE failed to show some such improvement. Other drugs, administered in the same manner, had different effects on behaviour, which suggests that the areas of the brain reached by this technique of injection are selectively sensitive to different chemical substances.

The search for relations between brain chemistry and behaviour becomes much more exciting when there is evidence that changes in biochemical events may be used to treat as well as create abnormal behaviour patterns. This search is not an easy one. The biochemical events themselves are extremely complex and difficult to untangle. New techniques must be developed and many more observations made before the processes which intervene between a biochemical change and its specific effects on behaviour can be described with any high degree of confidence. But the effect is well worth while, for here is a frontier of the biological sciences in which knowledge has great potential importance both to individual human beings and to society generally.

NOTE

*The substance of this paper was recently broadcast in "The Frontiers of Knowledge" by the BBC European Service.*

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# THE RETURN OF THE PLANET MARS


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On September 10, 1956, the planet Mars will be once more in opposition with the Sun and at its nearest approach to the Earth for fifteen years. It will then present itself for close investigation under conditions not to be matched again before 1971. This is indeed an opportunity that astronomers the world over are not going to let pass by without doing their utmost to solve some of the outstanding problems of our mysterious neighbour.

At its minimum distance to us—36 million miles—the disc of Mars will subtend to an apparent diameter of 24·7 seconds of arc—a penny at 285 yards. This is large enough to permit a rather detailed examination of the surface features of the planet, its white polar caps, its greenish dark spots and markings, its bright reddish desert areas and, occasionally, its transient whitish and yellowish cloud formations. Photography in violet or ultra-violet light will further disclose its atmospheric haze, high-level condensations, and associated phenomena. Infra-red spectrophotometry and radiometry will help ascertain its climatic conditions, and the chemical constitution of its atmosphere and surface.

ELEMENTS OF THE ORBIT AND GLOBE OF MARS

| | |
|---|---|
| Distance to the Sun: | |
| at aphelion | 155 million miles |
| at perihelion | 129 million miles |
| Distance to the Earth: | |
| at perihelic opposition | 35 million miles |
| at aphelic opposition | 62 million miles |
| Period of revolution (Martian year) | 687 (terrestrial days) |
| Period of rotation (Martian day) | 24h 37m 22·67s |
| Diameter of globe (equatorial) | 4200 miles |
| Polar flattening (theory) | 1/192=0·0052 |
| Polar flattening (observed) | 1/77=0·013 |
| Inclination of equator on orbital plane | 25 degrees |
| Mass (Earth=1) | 0·106 |
| Gravity (Earth=1) | 0·38 |
| Mean density (Earth=5·52) | 3·95 |
| Intensity of solar radiation (Earth=1) | |
| at perihelion | 0·52 |
| at aphelion | 0·36 |
| Duration of seasons: | |
| southern summer (northern winter) | 160 days |
| southern autumn (northern spring) | 199 days |
| southern winter (northern summer) | 182 days |
| southern spring (northern autumn) | 146 days |

## THE "SNOW" CAPS

The bright white "snow" caps which cover the polar regions of Mars are the most conspicuous features of the planet. Their seasonal evolution constitutes a fascinating phenomenon to follow, as they shrink from a vast icy expanse covering some 4 million square miles of the surface at the end of winter to a tiny, dazzling spot of minute dimensions as summer draws to its end. That they consist of ordinary ice, perhaps like hoar frost, had long been suspected but was not established until 1948 through infra-red spectrophotometry by the University of Chicago astronomer, Gerard P. Kuiper. He showed that the polar caps of Mars cannot resemble our thick snow and ice fields, but are more likely thin deposits of ice crystals on a frozen ground at a very low temperature. This was further confirmed in 1950, when A. Dollfus, of Meudon Observatory, succeeded in reproducing under laboratory conditions the polarisation he had observed in the light of the polar caps. This he achieved by provoking the formation of a thin layer of white frost deposited under reduced pressure on a copper plate cooled by dry ice, and then by illuminating it with the strong light of an electric arc so as to induce its evaporation (sublimation).

## THE "SANDY DESERTS"

The bright reddish areas which cover about three-fourths of the surface of Mars have long been regarded as sandy deserts coloured red by iron oxide. This hypothesis originally based on analogies of colouring, reflecting power (albedo) and general monotony, readily accounts for the yellowish veils which rise and spread over these areas from time to time as do dust and sand storms in our deserts. These early conjectures have also found much support in modern studies on the polarisation of light reflected by planetary surfaces and terrestrial materials. These studies, initiated over thirty years ago by the French astronomer Bernard Lyot, of Meudon Observatory, have been continued in recent years by A. Dollfus who, in 1950, found that a common substance, limonite (hydrated ferrous oxide), duplicates almost exactly the polarisation curve of Mars. However, an alternative identification, put forward by G. P. Kuiper in 1948, on the strength of his infra-red spectrophotometric studies, is felsite, an igneous rock consisting of a silicate of aluminium and potassium with quartz and other inclusions. Further tests and cross-checking will be necessary to clear up the ambiguity. Nevertheless it seems safe to conclude that although the exact mineralogical nature of the rocks constituting the bright area of Mars is still in doubt, the desert theory seems now well founded on a variety of fairly convincing arguments.

## ATMOSPHERIC COMPOSITION

More definite indications have been obtained on the chemical composition, physical structure, and gaseous pressure in the atmosphere of Mars. The problem of its chemical composition can be attacked from several directions: the dynamical theory of gases, which excludes light gases; the cosmical abundances of elements and chemical properties, which eliminate many others as unlikely candidates; spectral analysis which has failed to detect oxygen, one of the few not excluded by theoretical considerations. The absence of oxygen in the atmosphere of Mars is naturally of great importance in speculations on the possibility of life, past or present, on the planet. The first and so far single positive result

FIG. 1. Planisphere of Mars based mainly on the visual and photographic observations of 1939 and 1941. It shows most authenticated details observed on the planet during the late spring and early summer of the southern hemisphere. The seasonal and irregular changes of the Martian topography detract from the significance of a general and permanent map of the planet. North is at the bottom.


FIG. 2. Nomenclature of the principal details of the Martian topography. Most of the names used in the present nomenclature of Martian markings date back to 1877 when the first modern map of the planet was drawn by the Italian astronomer G. V. Schiaparelli.

of spectral analysis of the Martian atmosphere was obtained in 1947 when Kuiper detected a small amount of carbon dioxide, roughly double that in our atmosphere over an equal area.

The search for water-vapour has not yet reached finality; the indication is that the amount present on Mars is very small, probably less than 1% of its abundance on Earth; but, as a non-permanent gas subject to wide regional and seasonal fluctuations, water-vapour may still be found in appreciable quantity over some areas of Mars. Nevertheless it is generally agreed that an extreme dryness usually prevails over most areas of Mars. This is indeed in agreement with the desert-like nature of its bright regions.

The conclusion is that the bulk of the atmosphere of Mars must be made up of gases evading spectroscopic detection, fairly heavy, not too active chemically, and cosmically abundant. This narrows down our choice to nitrogen as the most probable constituent, with a small admixture of carbon dioxide and, possibly, of argon, as the decay product of the radio-active isotope of potassium present in the rocks of the crusts. Although uninviting to Man, this atmosphere is not, cosmically speaking, very different from that of the Earth.

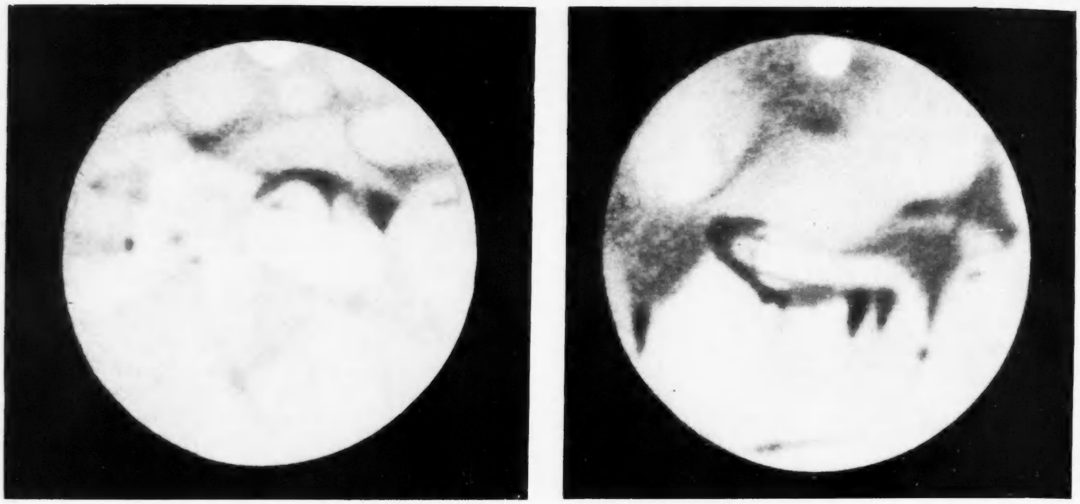


FIG. 3. Views of Mars as seen through the 8-inch refractor of the Peridier Observatory, Le Houga, France on September 11, 1941 (*left*), and September 23, 1941. These drawings show two opposite sides of the planet under very nearly the same presentation and seasonal conditions as they will appear in September of this year. Note the small southern polar cap, then in its summer, the dark tropical and equatorial areas, then at their seasonal maximum of intensity, the streaks of "canals", some broad and diffuse, others narrower and sharper, and the small dark lakes or "oases", at some of their intersections, in the bright desert areas.

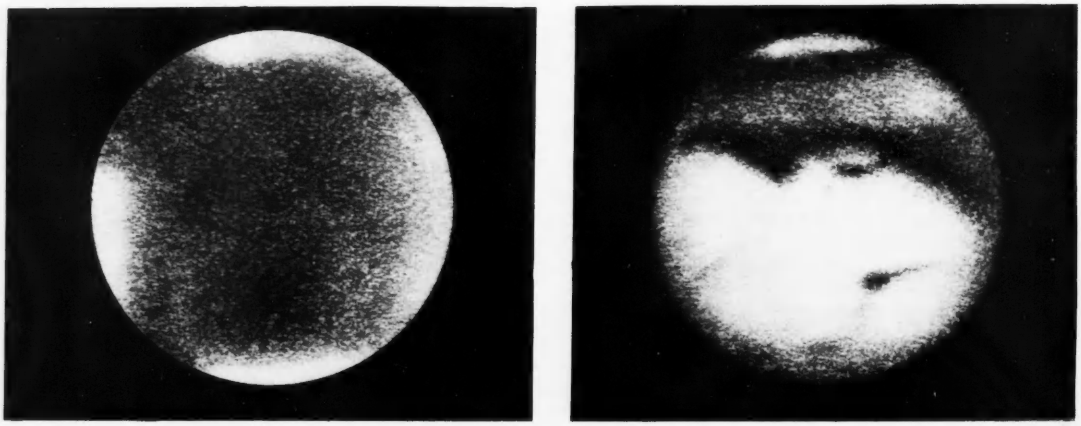


FIG. 4. Mars in ultra-violet (*left*) and infra-red light from photographs taken in 1939 by W. H. Wright with the 36-inch refractor of the Lick Observatory, California. The ultra-violet image shows only the atmospheric "violet layer" and associated blue clouds while the infra-red image shows with great intensity the surface markings and the south polar cap.

## ATMOSPHERIC STRUCTURE

The physical structure of the atmosphere of Mars was revealed by photographs taken through colour filters. Such pictures usually show the familiar surface markings only in yellow, red, and infra-red light; in blue, violet, and ultra-violet light on the contrary, the surface is habitually invisible and atmospheric formations only are recorded. In a few instances, however, the surface markings do remain clearly visible in blue light. As was first pointed out in 1937 by E. C. Slipher, at the Lowell Observatory, such instances of "blue clearing" prove that the usual opacity of the Martian atmosphere must be attributed to an absorbing and scattering layer of finely divided matter floating in the atmosphere and which clears only on rare occasions. The nature of this "violet layer" is still something of a mystery; mist of water ice, haze of dry ice crystals, even smoke of carbon particles . . . have all been suggested in turn during the last ten years, without conclusive evidence for or against any of these hypotheses. To complicate matters Slipher pointed out in 1954 that the periods of "blue clearing" seem to take place mainly within a few days of opposition, when the Sun, the Earth, and Mars are aligned, as if illumination geometry

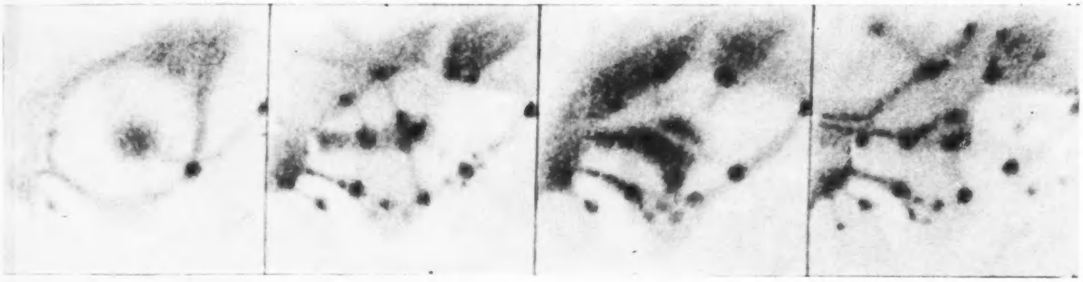
or perhaps magnetic screening of Mars by the Earth were of importance in producing the phenomenon. Its possible recurrence will be watched with keen interest during the first two weeks of September.

Visual and photographic observations have disclosed three main types of clouds on Mars: (1) "blue" clouds which appear as mere local condensations in the "violet layer" and probably share its (unknown) nature; (2) "yellow" clouds, which are probably dust storms originating in the desert areas (although the possibility that some of them are clouds of volcanic dust should not be dismissed yet); (3) "white" clouds which are probably made up of tiny ice crystals, like our cirrus clouds.

From the displacements of such clouds, wind velocities ranging up to 60 miles per hour have been detected on Mars and rudimentary weather maps have been constructed which bear some resemblance to those of our planet. The comparative meteorology and atmospheric circulation of the two planets is a field which may well prove of considerable practical value in the future.

## ATMOSPHERIC PRESSURE

The atmospheric pressure on Mars is an important element which was still largely hypothetical only twenty years ago. Since 1940, however, fairly accurate determinations have been obtained by French and Russian astronomers. These are based on an analysis of the photometric and polarimetric properties of the light reflected by Mars, part of which is due to the molecular scattering of sunlight in its atmosphere. The most probable value of the atmospheric pressure at ground-level on Mars derived from a general discussion of these determinations is about 2·5 inches of mercury or



1877 1924 1926 1941

FIG. 5. The region of "Solis Lacus" has suffered extensive non-seasonal changes in 1877, 1924, 1926, and 1941. Note the comparative stability of the minor dark spots contrasting with the widespread changes in the major markings. Temporary fertility or intermittent volcanic activity have been suggested as possible causes of such variations.

FIG. 6. The slow progress of planetary photography is illustrated by these two views of Mars taken in 1909 by E. E. Barnard with the 40-inch refractor of the Yerkes Observatory (*left*) and 1941 by B. Lyot and H. Camichel with a 15-inch refractor at the Pic du Midi Observatory. They show the same face of the planet at nearly the same Martian season (early southern summer). Note that the main configurations remain essentially unchanged despite some minor variations in detail.

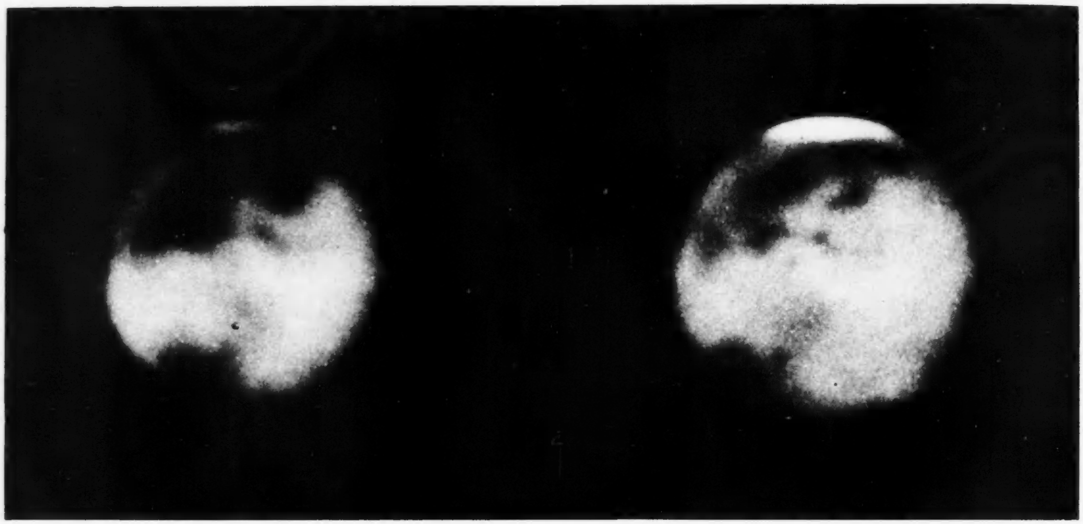


IMAGE ORTHICON. JULY 18, 1954.
LOWELL OBSERVATORY

EASTMAN III G (2) JULY 3, 1954
NATIONAL GEOGRAPHIC. LOWELL OBSERVATORY

FIG. 7. A new departure in planetary photography is illustrated by these two pictures of Mars obtained in 1954 by Lowell Observatory astronomers. The image at the left was recorded by R. Sturm and A. G. Wilson by means of an image orthicon attached to the 24-inch refractor at Flagstaff, Arizona; the amplified and intensified electronic image was projected on the fluorescent screen of a kinescope tube and photographed with an exposure time of only one-fifteenth of a second.

The direct photography at the right, given for comparison, was obtained by E. C. Slipher with the 27-inch refractor at Bloemfontein, South Africa with an exposure time of about two seconds.

The greater zenith distance of Mars at Flagstaff and the experimental nature of the apparatus are responsible for the poorer quality of the electronic image; much improved results are expected this year.

85 millibars. This is rather less than one-tenth of the sea-level pressure on Earth but, owing to the weaker pull of gravity on Mars (0·38 g), corresponds to a mass of gas equal to 22% of that above an equal area of the Earth. For the same reason the pressure in the atmosphere of Mars decreases with altitude much more slowly than on the Earth; while the surface pressure on Mars is comparable with that prevailing some 11 miles up in our atmosphere, equality of pressure in both atmospheres is reached at an altitude of about 17 miles and at still higher levels the pressure is greater in the Martian atmosphere than at the same altitude above the Earth. This may help explain why Martian clouds have been recorded at very high altitudes by terrestrial standards (up to 20 miles or more).

## TEMPERATURE AND CLIMATE

A quarter of a century ago W. W. Coblentz, C. O. Lampland, and D. H. Menzel at the Lowell Observatory, and E. Pettit and S. B. Nicholson on Mt. Wilson made astronomical history when they succeeded in measuring with the thermocouple the temperatures of the planets. Their measures were particularly successful and detailed in the case of Mars and gave for the first time a fair idea of climatic conditions on our neighbour planet. Further observations carried out at the Lowell Observatory in later years have been recently reduced and discussed by F. Gifford, while new spectro-radiometric studies with higher resolution were undertaken at Mt. Wilson in 1954 by W. M. Sinton and J. Strong, of Johns Hopkins University, in preparation for the present opposition.

The mean temperature of Mars is decidedly lower than that of the Earth, about −35°F as against +60°F, as could be expected theoretically, allowing for the respective distances to the Sun. However, at noon, in summer, in the tropics, when the planet is near perihelion, values well above freezing point have been recorded, reaching up to 60°F in the bright areas and almost 80°F in the dark areas which absorb more efficiently the solar radiation. Nevertheless the night and winter temperatures must be uncomfortably low by terrestrial standards, perhaps as low as −70°F at the end of the equatorial nights and −120°F during the long polar winter.

All in all the "climate" of Mars may be likened to that of a polar and stratospheric desert on Earth, if such a thing existed. Space-travel enthusiasts, please note.

## SEASONAL CHANGES

The dark markings which confer to the map of Mars its characteristic pattern present also the most perplexing phenomena observed on the planet. Patient studies have established that these dark regions, however permanent on the whole, are subject to considerable intrinsic variation in detail. Some changes are decidedly

seasonal in character, other are irregular and unpredictable. The seasonal variations affect the colour, brightness and polarisation of the spots, and may be triggered by the arrival in spring of water-vapour emanating from the polar regions. It looks as if water-vapour released by the polar cap in spring and summer spreads more or less uniformly towards the equator and beyond on its way to the other pole, where it eventually condenses again; this wave of humidity bounces back and forth from one pole to the other every six Martian months in a planet-wide distillation process. It has been suggested by many authors that the correlative changes observed in the dark regions constitute good evidence for the presence on Mars of some sort of primitive vegetation, perhaps not unlike the lichens and mosses of the Arctic tundras.

Some physicists, and even astronomers not too familiar with Martian phenomena, have, however, advanced purely inorganic theories to account for the seasonal changes on the surface of Mars. They rely mainly on suitably selected hygroscopic substances coloured by metallic salts which under favourable conditions conceivably might "do the trick"; but to most observers this looks suspiciously artificial. Another, more original hypothesis advanced by the American astronomer Dean B. McLaughlin in 1953, calls for extensive volcanic activity on Mars, the seasonal changes in the atmospheric circulation pattern being held responsible for changes in the amount and location of the dust and cinders deposited. This, McLaughlin claims, also accounts for irregular changes, temporary dark areas, and perhaps even for the whole of the permanent dark markings. This hypothesis has found little favour among experienced observers of the planet who, as is often the case in astronomy, "know too many facts to be satisfied with any hypothesis".

To many it still seems that the hypothesis of the existence of some form of plant life in the dark areas of Mars, although it cannot yet be considered as definitely established, provides the most likely explanation of the observed phenomena.

## "CANALS"

As for the famous-infamous "canals" of Mars so many heated arguments have been exchanged about them for more than three-quarters of a century that little worth saying can be added at present. Most astrophysicists prefer to busy themselves with other aspects of the problem of Mars which there is some hope of solving with present resources. That there are minor details in both the bright and dark areas of Mars is acknowledged by all, that some of these details tend to form linear patterns is accepted by most observers and that they display seasonal and non-seasonal variations is recognised by many; to this extent the "canals" of Mars are an established reality. It is only when it comes to discussing the fine structure and ultimate nature of these formations that agreement cannot be reached; perhaps it would be wise to admit that we are then attempting to force definiteness on something which lies at and probably even beyond the optical power of existing telescopic resources. Maybe the answer will not be obtained until the first rocket-ship lands on Mars. . . .

## ELECTRONIC PHOTOGRAPHY

Meanwhile attempts are being made to improve the sharpness of photographs by cutting down exposure time to such an extent that confusion by atmospheric turbulence may become unimportant compared with the theoretical resolving power of large telescopes. A promising experiment carried out in 1954 at the Lowell Observatory by R. Sturm and A. G. Wilson has led to the pictures reproduced here (Fig. 7) which were taken with an exposure time only one-thirtieth of that required for a conventional photograph. This was achieved by attaching an image orthicon to the 24-inch refractor and projecting the greatly enlarged electronic image on a kinescope screen which was finally photographed with a miniature camera. Although this first experiment has not succeeded yet in producing better images of Mars than conventional photographic techniques, it marks an important step in the right direction. Because of the higher quantum efficiency of the photoelectric layers compared with photographic emulsions much could be gained in principle by adapting electronic image converters, similar to those used in television, to optical telescopes; these new techniques were the subject of an important symposium held last year in Dublin during the meeting of the International Astronomical Union.

## INTERNATIONAL MARS COMMITTEE

Another important development for the progress of Martian studies was the organisation in 1953 of the "International Mars Committee" under the auspices of the Lowell Observatory and with the support of the National Science Foundation. By bringing together experts in the many branches of science which have a bearing on the problem of Mars: astronomy, geophysics and -chemistry, meteorology, etc., the Committee has already done much to renew interest in the subject. By further sponsoring co-ordinated research projects in many parts of the world and financing an international photographic patrol of the planet during the opposition of 1954, this Mars Committee has given added value and continuity to the various programmes.

It appears probable that with the continuation and development of this work during the present opposition our neighbour planet will be subjected to the most intensive and extensive investigation ever attempted. When the results are collected and evaluated in 1957 or 1958, knowledge of the planet is likely to make such progress as to relegate all earlier information to the pre-history of the subject.

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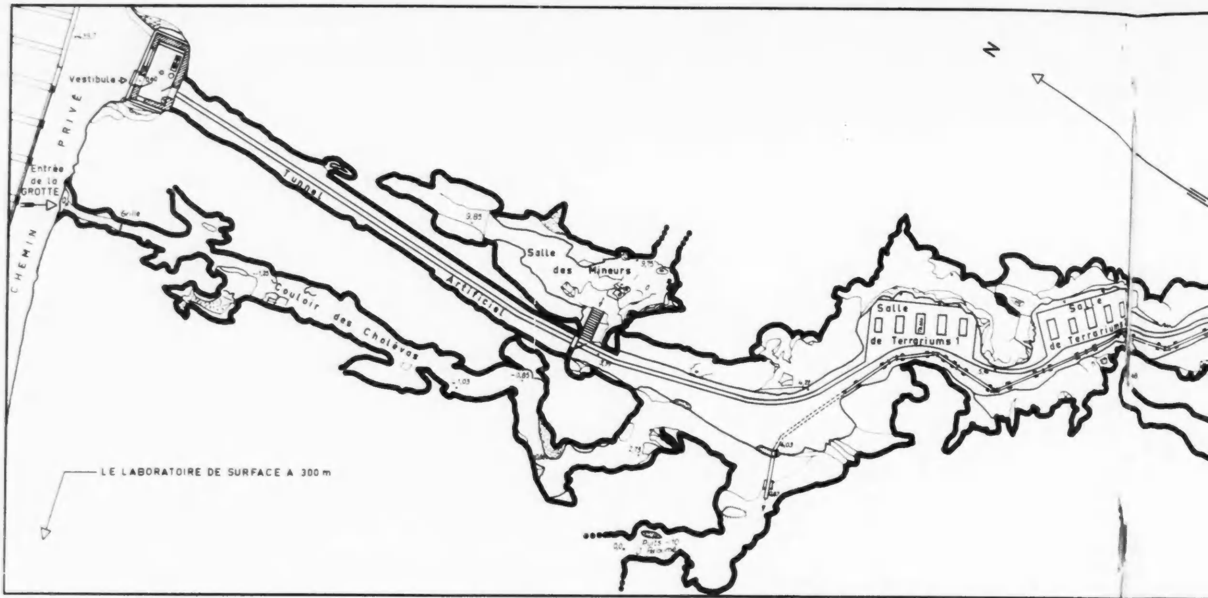


Map of the Moulis district. The triangles indicate peaks the black d

# THE CAVE LABORATO

**From a report by A. VA**

*Member of the French Academy of Sciences and Professor of Z*

In the 17th and 18th centuries the exploration of caverns began to attract interest: it remained, however, in the nature of a hobby until the 19th century. In recent years it has come to be considered as a separate branch of science, and learned societies devoted to the study of spelaeology have been founded in a number of countries. The spelaeologists, armed with the devices put at their disposal by advances in technology—electric lamps, oxygen supplies, nylon ropes, etc.—have been able to penetrate farther and farther into the underground recesses.

The cave explorers soon realised that discoveries of absorbing interest were to be made in the caves and grottoes, not only for prehistory and palaeontology but also for biology. It was known as early as the 17th century that the grottoes of Carniole on the borders of Austria, Italy, and Yugoslavia contained a strange amphibian, the olm, different from any animal found above ground: a scientific description of it was made in 1781 by the Austrian Laurenti who gave it the name of *Proteus anguinus*. Some fifty years later Count Franz von Hohenwart found, again in a grotto of Carniole, the first blind cave beetle, the *Leptodirus hohenwarti*.

This was the beginning of a wave of scientific exploration, particularly in Europe and in North America. The investigations were carried out at first by a number of enthusiasts working in isolation, but early in this century the Rumanian scientist Racovitza with his French colleague René Jeannel set up an organisation, *Biospeologica*, to encourage the collection of specimens of the fauna of caves, to distribute them among the various specialists, and to publish the results of their observations. The next step was to make a laboratory study of the mode of life of the cave-dwelling arthropods under conditions similar to those of their natural surroundings.

It seems that the first underground laboratory was designed by a Frenchman, Armand Viré, who in 1897 fitted up one of the galleries of the catacombs which stretch underneath the Jardin des Plantes in Paris. The laboratory was destroyed thirteen years later in the great floods of 1910 when the water swept through the catacombs. Twenty years afterwards, another "biospelaeological laboratory" was set up, this time in one of the galleries of the grotto of Adelsberg, or Postumia, part of the Carniole complex of caves, but the ambitious programme of research it was intended to carry out never seems to have been pursued.

In 1945 the French Association for the Advancement of Science met in Paris. Among the speakers was Prof. Jeannel, the founder, together with Racovitza, of *Biospeologica*. He called for the creation of a cave laboratory in France, and was able to obtain support for the project from the Centre National de la Recherche Scientifique, a French government research organisation which had been set up in 1930 to foster both pure and applied research in all branches of human learning.

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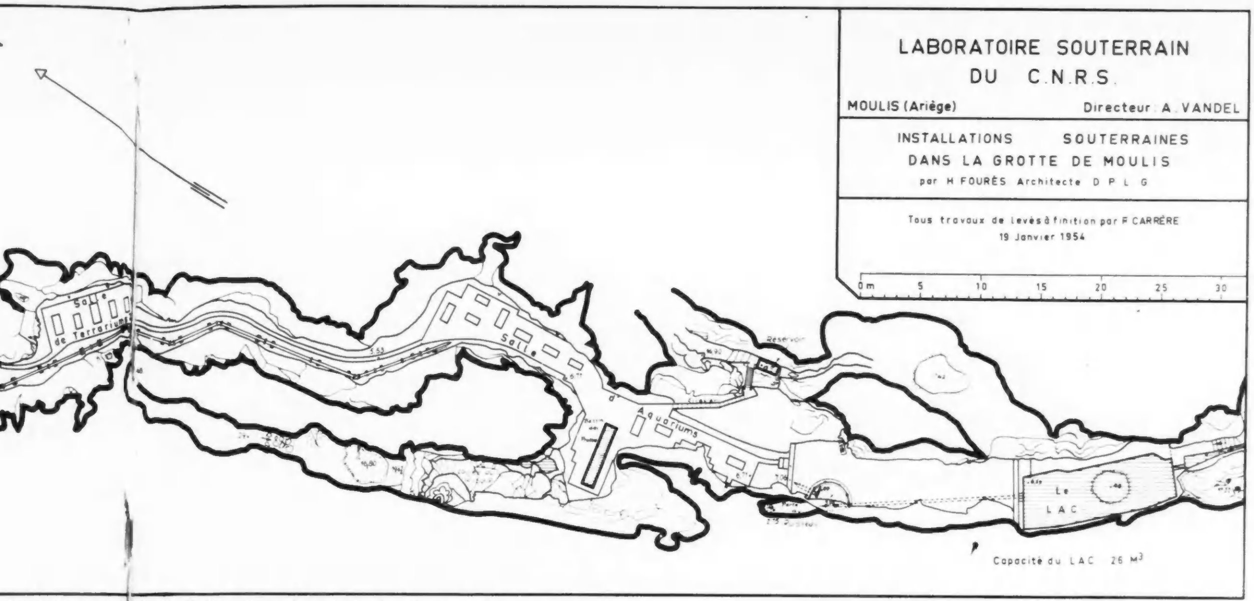


gles indicate peaks the black dots show the principal underground caves.

# ABORATORY OF MOULIS

**om a report by A. VANDEL**

*Academy of Sciences d Professor of Zoology at the University of Toulouse*

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## THE GROTTO OF MOULIS

A search was made for a suitable cavern in the Pyrenees, the region of France having the most numerous and most varied cave fauna. The grotto of Moulis, some 20 kilometres from the Spanish frontier, lies in the centre of an area studded with caves, many of which have still to be explored. It has abundant clay, numerous stalagmites, and a perpetual spring providing an ample water supply. It is easy of access, close to a village which could provide accommodation for the research workers, and near a source of electric power.

The natural entry was so small that the cave could only be entered on all fours. As this passage was inhabited by large numbers of *Choleva* beetles during their period of metamorphosis, it was decided to leave it intact and to bore a tunnel 50 metres long a short distance away. The new entrance led into the main gallery, which at the time ended in a narrow tunnel too small for a man to enter. Another tunnel was bored at this spot, and a further long gallery was discovered. The length of the accessible part of the grotto was thus increased to 900 metres.

The whole elongated gallery was fitted up to form three units, two containing "terrariums" for the study of the cave arthropods which live on land, and the third housing the aquariums for the water arthropods. The floor of the gallery was paved, and electricity was installed and brought to various points in the laboratory, with the power reduced to 20 volts as a safety precaution. The stream was dammed and made to fill a depression in the floor of the gallery; it was pumped from there to a tank which provided water for distribution by pipeline to the different laboratories. Drains were built to eliminate the waste water and also to provide an outlet when the stream became swollen after heavy rain or when, as often happens in underground caves, there was sudden flooding. An air compression system was installed to aerate the aquaria.

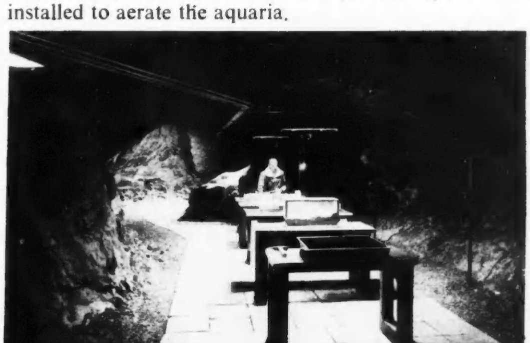

FIG. 1. One of the laboratory "rooms" showing the water, compressed air, and electricity supply lines.

*The illustrations are reproduced by courtesy of the Director of the Laboratory and the Centre National de la Recherche Scientifique, from the report "Le Laboratoire Souterrain de Moulis."*

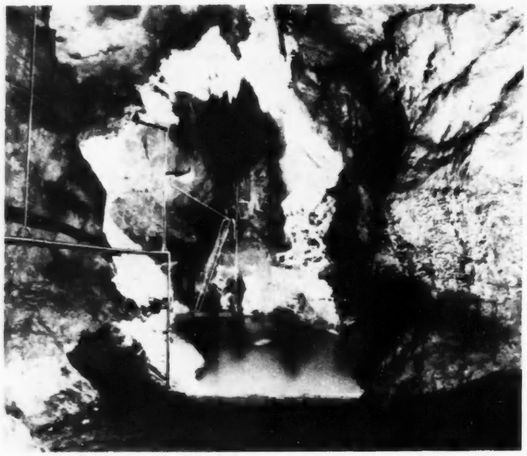

FIG. 2. The reservoir formed by the damming of the stream. The water is pumped from here, through the pipe seen on the left, up to the tank.

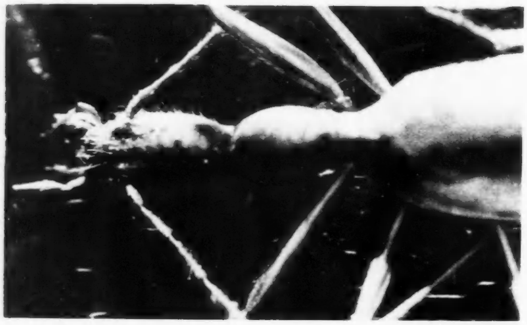

FIG. 3. Head and thorax of an *Aphaenops* beetle. Note the absence of eyes.

A small building was erected at the mountain entrance of the tunnel, to house the control switches and to act as a storeroom. A surface laboratory was constructed some 300 metres from the cave and about 100 metres from the village of Moulis. This contains more research units, including two controlled temperature rooms, a photographic unit, a meteorological post, a workshop, and a library.

The name given to the new research institute, "Laboratoire Souterrain de Moulis", was a deliberate choice, since the CNRS did not intend the activities of the laboratory to be limited to biological problems but wished it to serve for the study of all aspects of conditions underground—measurement of the ionisation of air in caves, hygrometric and thermometric investigations, research on crystallisation and on the formation of stalagmites and stalagtites, etc. At the moment the work of the laboratory is mainly concerned with the investigation of the mode of life of the cave-dwelling arthropods—their physiology, reproductive cycle, and behaviour.

## CAVE-DWELLING COLEOPTERA

Among the different cave-dwelling *Coleoptera* which have been bred successfully in the laboratory, are the *Speonomus longicornis* and *S. diecki* beetles, which have a curious life-cycle. The female lays one enormous egg every forty or fifty days. The primary larva is only active for a short period varying between a few hours and a few days; without having eaten or undergone any mutation, the larva builds a cell in which it enters a state of rest, lasting five months and ending with pupation and transformation into adult form.

Once the technique of breeding has been perfected, problems of genetics can be tackled. Because of their geographical isolation, the cave-dwelling arthropods form many different species, sub-species, and distinct races. Crossing of these different types should provide valuable pointers in the field of evolution.

The sex behaviour of the *S. diecki* beetle has also been studied, and observations have been made of its reactions to variations in temperature.

Work on the physiology of the cave dwellers has so far been directed towards checking and extending previous studies of two of the most striking characteristics observed in the majority of the cave arthropods —absence of pigmentation and blindness (in some cases absence of eyes). The first naturalists who examined the fauna of the grottoes assumed that these features could be attributed directly to the fact that the animals lived in darkness. It was observed later, however, that apart from the arthropods specific to the grottoes, other species are to be found for whom the cave is the preferred habitat but who have normal vision and pigmentation even though they never see daylight. Conversely, depigmentation is often found in animals which live in the light.

A sounder explanation seemed to be that depigmentation, accompanied by defective vision or blindness, was due to the conditions of damp and continuous cold prevailing in the caves. In 1931 Prof. Fage, taking as his starting point work by Mayer and Plantefol showing that the respiratory rate of mosses decreases with increases in water content, put forward the view that the cave spider, living in an extremely humid atmosphere, must have a very low oxidation rate which would in turn lead to depigmentation. Recent work carried out at Moulis and incorporating the findings of American workers on cave-dwelling arthropods, has confirmed the first part of Fage's hypothesis.

Perhaps the most fascinating investigation which has yet been carried out is that showing the high rate of salt tolerance of the *Spheromidae* a family of the isopod group of crustacea whose distribution in Europe closely follows the complicated contours of the Miocenean sea. This finding gives further support to the view that, though the present-day cave *Spheromidae* is a freshwater creature, it was originally a marine animal.

Much work remains to be done on these as yet unfamiliar cave animals, but the results of the research may provide important clues in the search for an explanation of the mysterious origins of man.

# ELECTRON MICROSCOPY OF SYNURA SCALES

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Synura is a genus of free-swimming unicellular organisms on the borderline between plants and animals. They are found mainly in late winter and spring in stagnant water, ponds, ditches, lakes, and flood water. Synura is a colonial organism: that is to say a number of cells, which are independent nutritionally, are united in groups. In this case the groups are in the form of spherical or oval masses (see Figs. 2 and 3). The cells are easily detached from each other and can live independently. They do not have a rigid cell wall, but are covered by a more or less flexible armour of overlapping silica scales. The various species of Synura are very much alike in appearance, and it has been found useful to distinguish them by the structure of their scales. These scales were examined in the electron microscope for the first time in 1954,* and they showed a wealth of ornamentation unsuspected from older methods of examination. They are singularly beautiful structures when seen in such detail.

## DETAILS OF ELECTRON MICROSCOPY

An important application of the electron microscope is the study of the submicrostructure of small particulate specimens, a category into which Synura scales fall. Such particles are generally prepared for examination by suspending them in a liquid and allowing a drop of the suspension to dry on a plastic film about 200 Å thick. The particles are thus distributed over the film and can be studied in the electron microscope. The amount of information obtained by examining particles prepared in this manner depends largely upon their thickness. If they provide little contrast in the electron microscope because they are too thin, their contrast must be enhanced by heavy metal shadowcasting. In this case a thin layer (10–20 Å) of heavy metal is deposited obliquely on to the particles by vacuum evaporation. The "shadows" cast by the metal appear light instead of dark in the electron microscope, thus micrographs of shadowed specimens are usually printed as negatives to give the impression that the specimen is illuminated obliquely by white light. In an examination of thick specimens only a silhouette is obtained, and shadowing provides little additional information. If the surface structure of thick objects is to be revealed, replicas must be employed.

## THE CARBON REPLICA PROCESS

The use of evaporated carbon as a replica material has been found to be more satisfactory than other materials because of its high resistance to chemical attack and the quality of the electron micrographs obtained. To produce a carbon replica, a suspension of the particles is dried down on to a glass slide. The particles and slide are then coated with about 200 Å of carbon by placing them a few centimetres below the points of two sharpened carbon rods held in light contact in a vacuum plant. The momentary passage of a current of about 40 amperes through the points causes the carbon to evaporate. The carbon film with the particles embedded in it is floated on to water and then transferred to a suitable bath to dissolve the particles, thus leaving a thin shell of carbon exactly conforming to the original topography. The replica is finally washed, dried, and shadowed.

Some idea of the value of the electron microscope in the study of Synura scales can be gained from a comparison of Figs. 2–5. Figs. 2 and 3, low-power optical micrographs of complete colonies of *S. petersenii*, show no scales at all. Fig. 4 is a high-power optical micrograph in which the shape of the scales of *S. uvella* is clear, but there is little detail visible. Fig. 5 shows a direct electron micrograph of a shadowed scale of *S. uvella*, and the fine sculpturing is clearly shown. In spite of the shadowing, which should produce a marked three-dimensional effect, an overall flatness remains. In Fig. 1, the replica of a scale of *S. uvella*, the three-dimensional effect is enhanced and the micrograph is more easily interpreted. The replica also shows the difference between the inner and outer surfaces of scales; both surfaces are clearly shown in Fig. 6. A comparison between a replica and an actual scale distinguishes between internal and external structure. For example, the ribbing in the rim of the scale in Fig. 4 does not appear in the replica shown in Fig. 1, since the ribs are internal. In order to obtain a complete picture of a scale it is therefore necessary to examine both a replica and an actual scale.

The carbon replica is of greater value in the study of completely opaque particles where little information can be obtained from the actual specimen.

## DESCRIPTION OF VARIOUS SYNURA SCALES

*S. petersenii* Korsch seems to be the commonest European species. The appearance of colonies from different localities varies somewhat. Sometimes the outline of the cell appears smooth and sometimes notched. The electron microscope reveals that the scales of all the variations are of the same pattern. The central ridge may be poorly developed (Fig. 6), when the cell outline will be smooth, or the central ridge may be strongly developed, even projecting as a short spine (Fig. 7) when the cell outline will appear notched. The latter type resembles one found in America and called *S. caroliniana* Whitford, while a smooth type from

* Manton, I., "Observations with the Electron Microscope on *Synura caroliniana*", *Proc. Leeds Phil. Soc.*, vol. 6, p. 306.

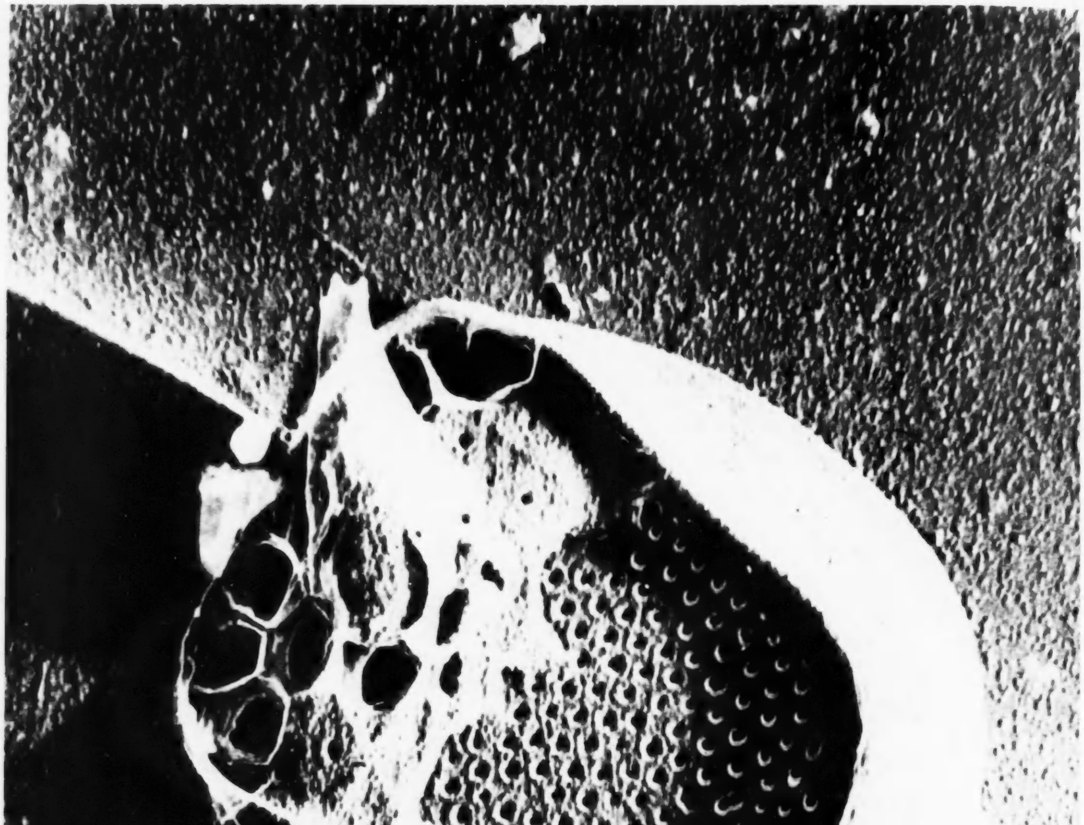
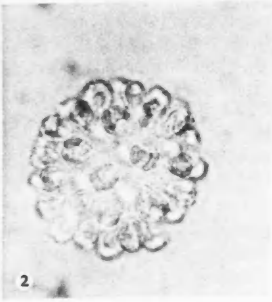
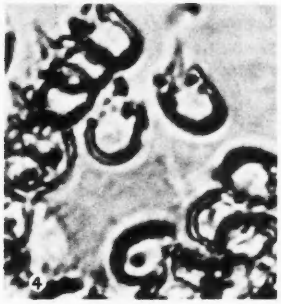
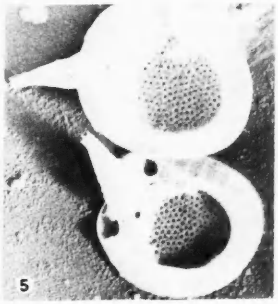
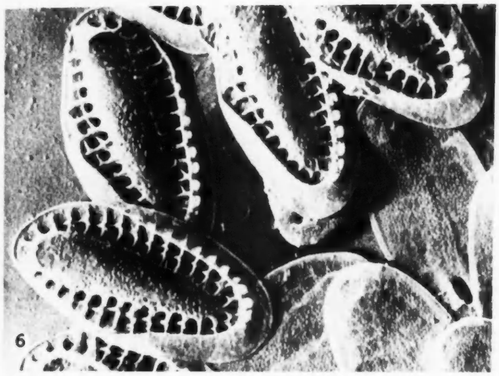


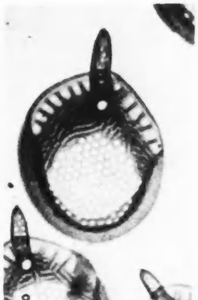

FIG. 1. An electron micrograph of a carbon replica of a scale from the body of *S. uvella*, a minute organism found in many ponds. Magnification: $\times$30,000.

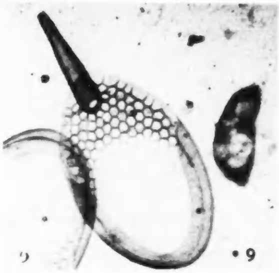


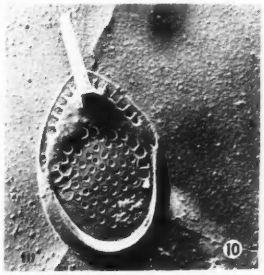












FIGS. 2 and 3. Optical micrographs of *S. petersenii* taken alive. FIG. 2. Complete colony, × 200 diameters. FIG. 3. Colony of a few cells showing their connexions, × 250 diameters.

FIGS. 4 and 5. A comparison between optical and electron micrographs. FIG. 4. Optical micrograph of the scales of *S. uvella* mounted in a medium of high refractive index, × 2500. FIG. 5. Direct electron micrograph of shadowed scales of *S. uvella*, × 5500.

FIG. 6. A shadowed carbon replica of the scales of *S. petersenii*, showing inner and outer surfaces, × 8500.

FIGS. 7 and 8. Direct electron micrographs of unshadowed scales. FIG. 7. *S. petersenii* scales showing a strongly developed ridge (cf. *S. caroliniana*), × 9500. FIG. 8. *S. echinulata*, × 10,000.

FIGS. 9 and 10. *S. spinosa*. FIG. 9. Direct electron micrograph × 7000. FIG. 10. Shadowed carbon replica × 6500.

FIG. 11. An electron micrograph of the shadowed scales and spines of an unknown organism close to Synura, × 11,500.

Europe has been named *S. glabra* Korsch. Another structural difference is shown in these two micrographs, in Fig. 6 there are cross bars joining the "spokes" in the scale, whereas in Fig. 7 these are absent. Intermediates between the different variations are found, and the species needs fuller investigation. It is possible that, in this instance, the more powerful magnification may lead to a reduction in the number of species, whereas it more commonly leads to the recognition of new ones.

Figs. 8, 9, and 10 show the scales of other more or less common species. In each of these the pattern of the sculpturing on the scales is characteristic, though the general shape of the scale is rather similar. All these species have been distinguished, and rightly, by the use of the light microscope, but the distinction is not easy. Now the electron microscope makes it clear and unmistakable.

Fig. 11 shows the scales and spines of some ally of Synura. It is an entirely unknown organism first recognised in this electron micrograph. Clearly, a search with the optical microscope must be made next season before this strange form can be described.

*One of the authors, D. E. Bradley, would like to thank Dr. T. E. Allibone, F.R.S., Director of the AEI Research Laboratory at Aldermaston for permission to publish this article.*

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# EIGHTY-TWO YEARS OF SCIENTIFIC CINEMATOGRAPHY

BRIAN W. COE

*At present two exhibitions in London are celebrating the sixtieth anniversary of the first screening in Paris of Lumière's first films. One exhibition, organized by the* Observer, *deals with the cinema as an entertainment art; the other, organized by Kodak Ltd., shows cinematography in its technological aspects.*

This year cinematography in Great Britain reaches its sixtieth birthday, although scientific cinematography may be said to be a full twenty-two years older, Janssen having used a crude type of cine camera to record the transit of Venus across the sun as early as 1874. On February 20, 1896, at the Marlborough Hall of the Polytechnic, Regent Street, Monsieur Trewey, the agent for the Lumière brothers, presented the first public performance of projected motion pictures, as we know them today, by means of the Cinématographe. Within a few weeks "animated photographs" were on show at most music-halls, many of them taken and projected by apparatus built by R. W. Paul, the leading British film pioneer. These events were the culmination of nearly a century of research and invention, for the introduction of "moving pictures" was not the work of any one man or of any one country. The origins and development of cinematography are closely bound up with the advances in scientific knowledge that were made in the 19th century.

The origins of "moving pictures" are very old. From the work of prehistoric cave artists depicting animals in various phases of movement, to the use of silhouettes—represented in its most elaborate form by the Chinese Shadow plays—man through the ages has attempted artificially to simulate the world of motion around him. An important advance was made by the introduction of the "magic" lantern, usually credited to the Jesuit, Father Kircher, who described such a device in 1645.

The "magic" lantern was at first used to project transparent pictures painted on slips of glass or mica, but by the end of the 18th century it was in use to show pictures that moved. Lantern slides in which movement was given to a portion of the projected picture by means of levers and gears, or slipping glasses, were a standard part of any lantern entertainment and were used well into the present century.

## THE PERSISTENCE OF VISION

The phenomenon of persistence of vision makes possible the motion picture of today. The fact that the eye retains for a short period (1/12th of a second or less) the impression of a moving object after the image of that object has been removed, had been noted by Ptolemy, in his second book on Optics, written about A.D. 130. It was referred to by many later philosophers and scientists, among them Leonardo da Vinci, Newton, and Boyle, all of whom merely mention the effect, apparently without having carried out any practical investigation. The first theoretical account was given by Dr. P. M. Roget in a paper to the Royal Society in 1824, in which he described the apparent distortion of the spokes of a wheel when seen in movement through a fence.

Between 1828 and 1831 other scientists, in particular Aimé, Faraday, and Plateau, referred to the fact that when two cogged wheels with equal number of teeth revolve at equal speed in opposite directions, one in

front of the other, the eye, if placed at a sufficient distance, will see a stationary image of one wheel only, resulting from the strong image formed when the aspects of the two wheels coincide. To demonstrate this effect Faraday constructed the so-called "Faraday's Wheel". In November 1932 Plateau introduced the first device which produced an illusion of motion by means of persistence of vision. Called the "Phenakistiscope", it took the form of a cardboard disc, on the surface of which was printed a series of images representing consecutive phases of motion, radially disposed. Round the circumference was a series of slots, equal in number to the number of images. The disc, rotated on its axis, was viewed by reflection in a mirror, the eye being applied to the slotted circumference. The opaque sections of the disc's circumference acted as a shutter, cutting off the sight of each image until the disc had moved far enough for the next image to take its place, at which time the next slot passed in front of the eye. By persistence of vision the rapidly superimposed images were blended by the eye into one continuously moving figure. With this invention, Plateau made a big step towards cinematography. Born in 1801, he devoted his life to the study of optics, in particular physiological optics. While investigating the effect of light upon the retina he exposed his eyes for a considerable time to the full glare of the sun, and he went blind at the age of twenty-eight. He recovered temporarily for a few years, during which time he invented the Phenakistiscope. After being appointed Professor of Physics at Ghent in 1835, his sight gradually deteriorated, and by 1843 he was permanently blind. He continued to engage in research on vision and optics. Relatives carried out his instructions for experiments to confirm his theories, and in this way he made many important contributions until his death in 1884.

## WHEEL OF LIFE

In subsequent years a number of modifications to the Phenakistiscope appeared, among the more successful being the Zoetrope, described by Horner in 1834 and introduced by Desvigne in 1858. Instead of being arranged on the surface of a disc, the images, usually thirteen in number, were printed on a band of paper which was placed around the inside of a shallow cylinder, into the walls of which were cut thirteen vertical slots. More convenient in use than the Phenakistiscope, the Zoetrope enjoyed a popularity which lasted into the 20th century (Fig. 1).

A number of devices were made by which the moving images obtained by this principle could be projected, one of the most successful being the Wheel of Life, invented by Ross in 1871. This employed a glass disc bearing thirteen images, arranged like those of the Phenakistiscope, which could be rapidly rotated by a belt-and-pulley mechanism. On the same shaft, but rotating in the opposite direction and at thirteen times the speed, was an opaque disc with a cut-out sector.

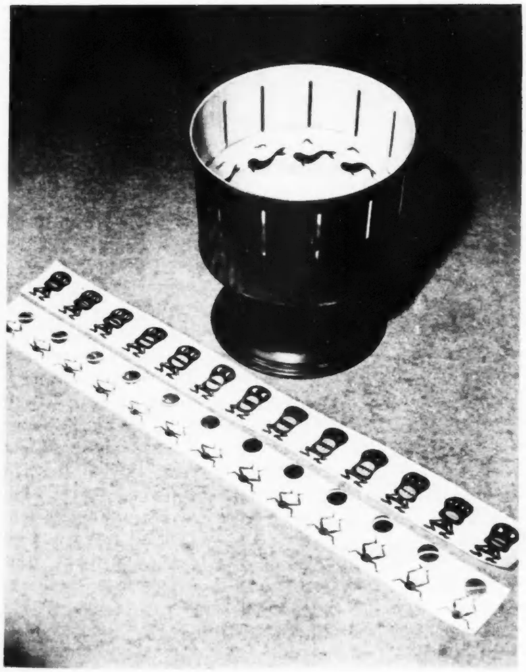
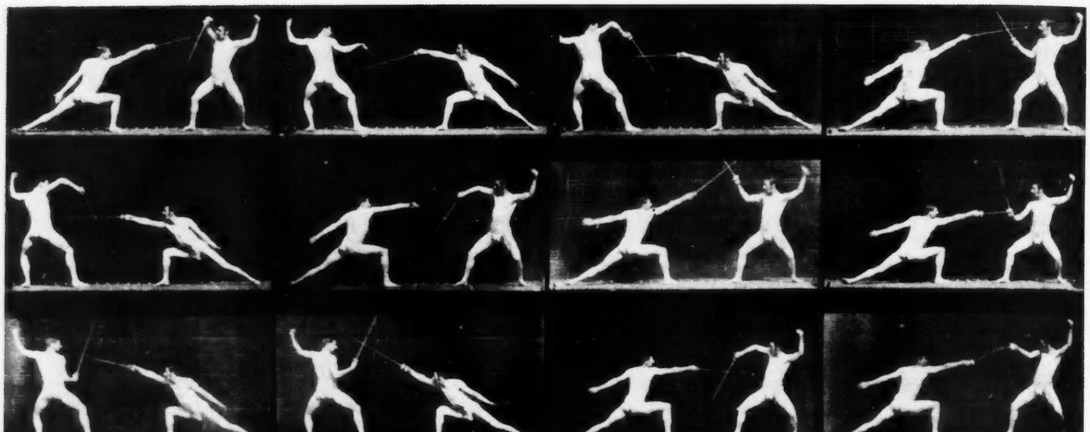


FIG. 1. The Zoetrope, 1860.
(*Courtesy of Kodak Museum.*)

FIG. 2. The Praxinoscope Theatre of Reynaud, 1884.
(*Courtesy of Kodak Museum.*)



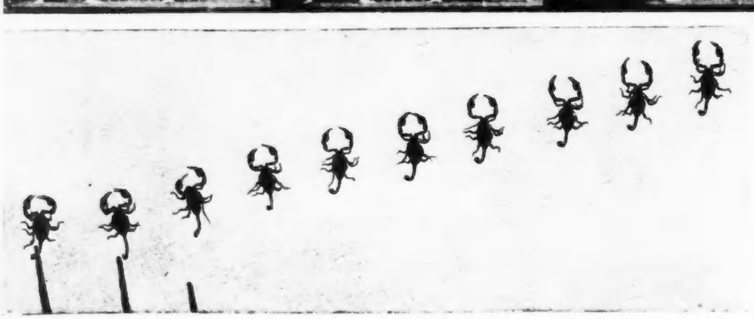


FIG. 3. Athletes fencing, photographed by E. Muybridge and published in 1887 in his classical book, "The Human Figure in Motion".

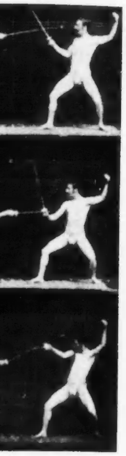
FIG. 4. The walk of a scorpion, filmed by E. J. Marey and published in his classical book "Le Mouvement" in Paris in 1894. Note the pair of tweezers in the bottom left-hand corner, which are releasing the scorpion for its walk.

Successive images were exposed by the sector when the picture disc had moved forward the distance between two images. The whole apparatus was of a size which could fit on the stage of the optical lantern. In later years many people were to make use of this system to project moving pictures, notably Muybridge and Demeny.

The principal disadvantages of this method were great loss of light on projection, as well as distortion and blurring of the images, because the rapidly rotating images were viewed through a shutter rotating at the same speed in the opposite direction. The solution to these difficulties lay in allowing each image to become momentarily stationary while projected, the movement between images being covered by some form of shutter. This is the basis of cinematography. A device introduced by Beale, and modified by Hughes in 1884, made use of such an intermittent system, effected by a modified "Maltese Cross" mechanism; the movement of the disc or slide bearing the images being covered by an oscillating shutter. A second method of avoiding the difficulties inherent in the Phenakistiscope principle was first introduced by Reynaud in 1877. A band of coloured images, similar to those in use for the Zoetrope, was viewed by reflection, as a virtual image, in a mirror drum in the centre of a shallow cylinder. The picture band was placed round the inside of this cylinder, the number of facets on the mirror drum being equal to the number of images. Matters were so arranged that the virtual image appeared to be at the axis of the cylinder, so that each image appeared to the observer to be stationary until it was rapidly and continuously replaced by the next. Reynaud called his apparatus the "Praxinoscope"; he later made several modifications, including a projection Praxinoscope, the Praxinoscope Theatre, and the Théatre Optique, in which long bands of transparent material carrying hand-drawn images were employed (Fig. 2). Reynaud himself drew the picture bands, which were from 20 to 50 metres in length; they had perforations and these engaged the pins on the wheel carrying the mirror drum. The Théatre Optique was patented in 1888 and was used to give public performances in Paris from 1892 to 1900, with a total of over 12,800 performances. The honour of the first commercial exploitation of projected animated pictures must thus be accorded to Reynaud, a man of great ability and ingenuity.

## CHRONOPHOTOGRAPHY

With the foregoing devices the principle of synthesis of motion from drawn images had been established; the problem to be solved before cinematography became an accomplished fact was that of photographic analysis of motion. After the introduction of photography in the 1830's and 1840's, attempts were made to obtain series



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of photographic images for use with the Phenakistiscope or Zoetrope. The lengthy exposure required for the early photographic materials meant that the first experiments had to be limited to the photography of models or machinery in various predictable positions. As instantaneous exposure became a possibility, various devices were patented which employed mechanisms to move glass plates rapidly and in succession behind the camera lens. One of the first was issued in France to DuMont in 1861. In 1876 Wordsworth Donisthorpe filed a patent in this country for a similar device. In a letter to *Nature* (1) in 1878, Donisthorpe suggested that the series of pictures from his "Kinesigraph" camera could be printed on a band of paper which could be intermittently illuminated by an electric spark. The short duration of the spark would render the images effectively stationary while it was continuously wound past a viewing aperture. He suggested that his "moving pictures" thus obtained could be combined with the Edison phonograph, recently invented, and that the two could be used to record plays, which could later be re-enacted on the screen.

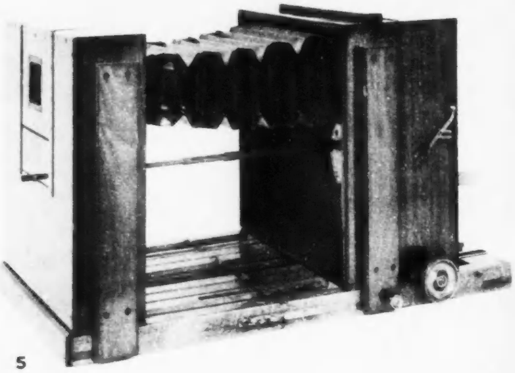
It was, however, the work of a number of scientists, investigating animal and human locomotion, which paved the way for the introduction of cinematography. The use of "Chronophotography" in the study and analysis of movement resulted in the stimulation of invention and research which led to the modern motion picture.

The first scientist to make use of the principle of the taking of photographs in rapid succession was the French astronomer Janssen. In order to record the transit of Venus across the sun in 1874, he constructed the "astronomical revolver" with which forty-eight images were taken round the edge of a circular daguerreotype plate in seventy-two seconds. The plate, intermittently rotated by clockwork, was exposed by a rotating disc shutter, which covered the plate while it was moving.

One of the most famous "Chronophotographers" was Eadweard Muybridge, a native of Kingston, who spent much of his life working in America. In 1877, in order to investigate the locomotion of the horse, he arranged a battery of twenty-four cameras, their shutters operated first by strings running across the course in front of the cameras, but later by electromagnets energised by an adjustable commutator. By this method he obtained series of photographs of the horse in movement in front of the camera. These could be recombined in the Zoetrope to give a moving picture. He finally set up three banks of twenty-four cameras each. Their shutters operated synchronously and they photographed an action from three angles simultaneously. With this apparatus he took many thousands of photographs of animals and men in movement (Fig. 3), and with his projection apparatus, which he named "Zoopraxiscope" and which was similar in principle to the Ross "Wheel of Life", he lectured all over the world from 1882 onwards, his excellent pictures undoubtedly arousing interest in the problems of analysis and synthesis of movement. It is known (2) that Edison had discussed with Muybridge the problems of chronophotography, while Muybridge's visit to England in 1889 prompted much discussion and investigation. Ottomar Anschütz, of Lissa, Austria, employed a similar battery of cameras, using efficient focal-plane shutters to obtain a number of series showing locomotion of animals and men, remarkable for their high photographic quality. He devised a modification to the Zoetrope for viewing his results, naming it the "Tachyscope". Later he built an apparatus in which transparencies from his series of negatives were placed on a large disc and were intermittently illuminated by a flashing Geissler tube.

## MAREY'S CONTRIBUTION

Prof. E. J. Marey, a French physiologist, all but solved the problems of cinematography. Devoting his life to the study of animal movement, his earliest experiments were carried out with the kymograph, which he used to study the movements of the horse, the wing-beats of bees, and even the wing-movements of a pigeon in flight. After seeing the early work of Muybridge, whom he met in Paris in 1881, he realised that chronophotography would provide the perfect recording medium for animal locomotion. In 1882 Marey constructed a "photographic gun" based on Janssen's astronomical revolver. A circular dry-plate was intermittently rotated by clockwork, while a shutter alternately covered and exposed the plate, which carried twelve pictures. The camera, which Marey described in 1882, in *La Nature* (3), was used to photograph the flight of birds. The long barrel contained a long-focus lens, the gun shape being convenient for sighting. The small number of possible exposures was a drawback, and Marey's second apparatus employed a single fixed plate with a rotating shutter, which gave a series of partly overlapping pictures of the moving object, after the fashion of a modern stroboscopic flash photograph. Although he derived much useful information from these pictures, the disadvantages of the apparatus, such as the necessity to have a black background and the occasional difficulty in separating the images, prompted him to devise another camera. In 1887 he built one which employed a band of paper-negative film, 9 centimetres wide by 4 metres in length, the film being wound from a feed spool to a take-up spool, and being intermittently clamped in the exposing aperture while a disc shutter made the exposure. On October 29, 1888, he demonstrated the camera and results to the Académie des Sciences (Fig. 5). The demonstration was widely reported in the international scientific and photographic Press; the *Photographic News* for November 16, 1888, (4) referred to Marey's pictures of swimming fish, taken at "five in 1/10 of a second". When sensitised celluloid film became available in 1889, Marey made minor modifications to his camera and employed 9-centimetre-wide celluloid film, carried on daylight loading spools, the apparatus being capable of exposing at 60 frames per second or faster (5, 6). In later years this and similar apparatus were used to make classical contributions to the knowledge of the locomotion of animals (Fig. 4). Undoubtedly this great physiologist deserves the title of



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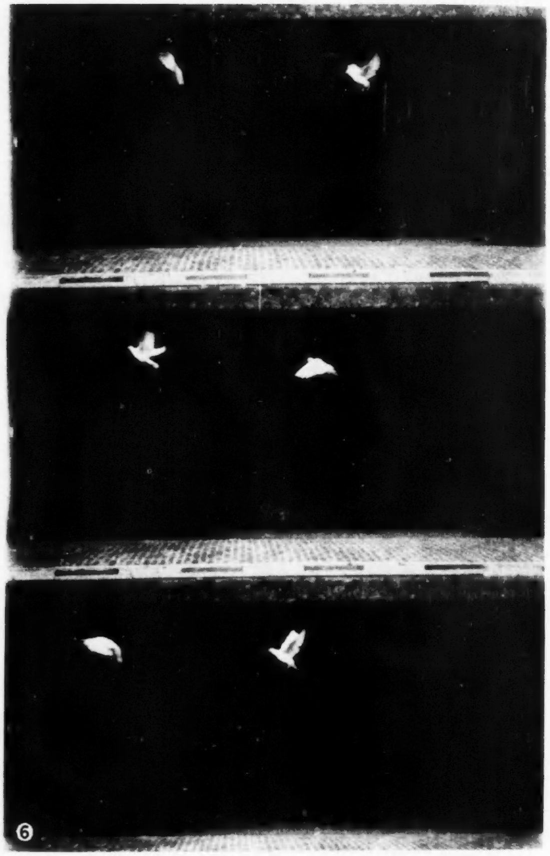
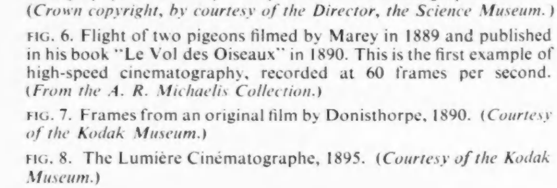


FIG. 5. Marey's "chambre chronophotographique", as described by him in 1888. This camera, embodying the principles of modern cinematography, was used by Marey for all his cinematographic records. (*Crown copyright, by courtesy of the Director, the Science Museum.*)

FIG. 6. Flight of two pigeons filmed by Marey in 1889 and published in his book "Le Vol des Oiseaux" in 1890. This is the first example of high-speed cinematography, recorded at 60 frames per second. (*From the A. R. Michaelis Collection.*)

FIG. 7. Frames from an original film by Donisthorpe, 1890. (*Courtesy of the Kodak Museum.*)

FIG. 8. The Lumière Cinématographe, 1895. (*Courtesy of the Kodak Museum.*)



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"first cinematographer" (7). He introduced, among other things, the techniques of high-speed (slow-motion) (Fig. 6) and time-lapse cinematography, and cine-micrography.

A demonstrator of Prof. Marey's, Georges Demeny, carried on some personal investigations into the recording of facial and other movements, with the aim of producing moving pictures to aid in the instruction of the deaf. His first apparatus, the "Phonoscope", worked on very similar principles to Ross's Wheel of Life; after dissociating with Marey, Demeny in 1893 devised a camera for flexible film, in which the "dog" or beater intermittent movement, much used in the early years of cinematography, was introduced.

## OTHER PIONEERS

Marey, like his fellow chronophotographers, was content to analyse his results frame by frame. The projection of motion pictures was, to him, of little importance.

The events leading to the establishing of cinematography as an industry in 1896 can only be treated in outline here; more detailed technical information can be obtained from other standard sources (8). Four patents for animated picture apparatus were issued in Great Britain before 1890. The first was to L. A. A. LePrince, on January 10, 1888. It described mainly a curious multiple-lens camera of rather impractical design (now in the Science Museum) and a similar projector; but most of LePrince's work seems to have been done with a single-lens camera (also in the Science Museum). LePrince was a man of talent and ingenuity; he disappeared mysteriously while on a visit to France in 1890 with a new camera, and was never heard of again (9).

The next patent, for a camera for taking photographs in rapid series, was issued to W. Friese Greene and M. Evans, on June 21, 1889. Much has been claimed for this patent and the apparatus it describes; contemporary records do not support the claims made for it in later years. It describes a camera for unperforated paper film, with an exposure rate of two or three frames per second. The surviving pictures taken with it are not of very high quality, and on the evidence of this patent and from contemporary records (10) there is no basis for the statement that Friese Greene was the "inventor" of cinematography.

Less than two months after this patent, Donisthorpe, whom we have already mentioned, filed a patent with W. C. Crofts for an animated picture camera and projector of unusual design. The only known surviving sample of film taken with this apparatus is in the Kodak Museum, and frames from it are reproduced here (Fig. 7). It seems that this camera, although curiously constructed, worked satisfactorily, at a speed of 10 frames per second; the quality of the original is surprisingly good.

The first patent for a stereoscopic camera and projector for photographs in rapid succession was granted to F. H. Varley, March 26, 1890. Often erroneously attributed to Friese Greene, the camera described in the patent was simple but ingenious, but was not intended to operate at speeds greater than four or five frames per second.

These early patents are evidence of the great interest in the problems of recording and reproduction of movement; however, the work of LePrince, Friese Greene, Varley, and Donisthorpe does not seem to have had any influence on the later development of cinematography.

## EDISON AND LUMIÈRE

The greatest single contribution to the introduction of cinematography was made by Edison and his colleagues. After two years of experiment, in 1889 they obtained from George Eastman some samples of the new celluloid film, and they constructed a camera employing film 35 millimetres ($1\frac{3}{8}$ inches) wide, with four rectangular perforations on each side of the frame, essentially the same as in modern practice. After patenting the camera in 1891, Edison also devised a peepshow viewing device, called the "Kinetoscope", operating by a simple modification of the "Phenakistiscope" principle. The Kinetoscope, patented in 1891 and marketed all over the world from 1893 onwards, was the first device to exploit photographic motion pictures, carried on celluloid film, 35 millimetres wide, transported by sprocket wheels engaging in perforations along the edge of the film. After his earliest experiments and demonstration (11, 12) Edison abandoned projection in favour of peepshow viewing—as he thought this method likely to be more profitable.

Stimulated by the introduction of the Edison Kinetoscope, Lumière, in France, carried out experimental work culminating in the design of a combined camera, printer, and projector which was patented in February 1895. The apparatus, the "Cinématographe", using a claw mechanism for transporting the 35-millimetre film, was first demonstrated at a meeting in March 1895; after other demonstrations the Lumières opened the first regular public showings of projected animated pictures, with payment for admission, at the Grand Café, Boulevard des Capuchins, Paris, starting on December 28, 1895 (Fig. 8). Charging an entrance fee of 1 franc, they took 33 francs the first day; three weeks later, takings were 2000 francs a day. In 1896 Lumière's agent, the conjurer Trewey, began to hold demonstrations at the Regent Street Polytechnic; Robert Paul, who had for the previous twelve months been engaged on experiments on cinematographic apparatus, became the first Englishman to give public performances of animated photographs. His "Animatographe" apparatus and films were shown at Olympia and at the Alhambra. Paul can truly be described as the "father of the British Film Industry".

## MAREY'S PREDICTION

In 1899 Marey (13) predicted the future trend of cinematography:

"Chronophotography was born for the needs of science . . . (but) it has had the good luck of interesting the public with its delightful illusions. . . . So perfectly

are familiar scenes reproduced that we begin to tire of seeing them. . . . Already the search for unusual subjects has begun; from far-off countries new spectacles are demanded, which soon will themselves be insufficient to maintain interest. It is then that Chronophotography, returning to its origins, will once again become scientific. . . . It will show the innumerable animal species in all the actions of their lives, those which fly in the air, those swimming in the waters and even those which are visible only in the field of the microscope. It will show the phases of the flowering of plants and the mysteries of their fertilisation; all kinds of machines in motion, the manufacture of all the products of human industry. Chemistry also holds surprises for us with its varied crystallisations and the strange forms, which, born in the mixture of certain liquids, sometimes resemble living organisms. . . . By simply changing the speed of movements which it reproduces, Chronophotography uniquely facilitates the observation of nature. But more can be asked of it. A movement, to be properly understood, must be exactly measured in the two elements which constitute it: space and time: these two dimensions must be brought to a common measure. . . . This has been achieved by Chronophotography."

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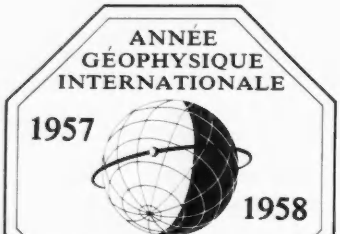


# THE INTERNATIONAL GEOPHYSICAL YEAR

## MONTH BY MONTH

**Compiled by Angela Croome**

*This month the Russians are to the fore with the remarkable oceanographical work they are doing from ship-borne laboratories, particularly in the Antarctic. They also took a prominent part in the CSAGI Arctic Conference in Stockholm.*

*Africa is in the news with the announcement of the Nigerian Programme, including its work on the ionosphere and geomagnetism, and also with the surveying of the Gambia river bed.*

**Planning**

Prof. S. Chapman, President of CSAGI (the central organising body of the IGY), was present at the Western Hemisphere Conference that took place in Rio de Janeiro between July 16 and 21. The conference organiser was Dr. E. O. Hulburt, Western Hemisphere CSAGI Joint Secretary. The Pan-American Institute for Geography and History collaborated with CSAGI delegates to draw up the final IGY programme for this region. A report of the proceedings will appear as soon as this is available.

The third annual meeting of the central planning body, CSAGI, will take place in Barcelona from September 10 to 15, when the work of ACIGY (the Advisory Council for IGY, which first met at last year's Brussels Conference) will play an important part. It was foreseen that, from this period on, IGY planning would be carried on by CSAGI as advised by ACIGY, and that individual countries would put forward their proposals through the advisory body. For this reason the Secretary-General urges that all countries participating send a delegate to ACIGY's meetings at Barcelona. National delegates may be assisted by any technical advisers and interpreters that they deem necessary (but unfortunately no CSAGI funds are available for those attending ACIGY meetings). The first meeting of ACIGY at Barcelona will be on September 11, a day later than that of CSAGI. At the end of the sessions there will be a symposium on the IGY artificial satellite research programme.

Note on ACIGY taken from Prof. Chapman's remarks:

The general purpose of the body is to advise and assist CSAGI on general IGY questions. For instance, ACIGY might usefully discuss problems of mutual help between participating nations, such as loans or gifts of instruments, training facilities or technical advice, also arrangements for the provision and distribution of archives.

Accommodation and facilities for work on the territory of one nation by IGY scientists from one or several others, though likely to be a material help to the IGY programme, is not an appropriate subject for ACIGY discussion or recommendation, since the project is strictly non-political and therefore cannot deal in matters concerning national territory. But CSAGI would welcome information that might be presented to ACIGY concerning any such mutual agreements between nations.

Delegates' proposals for participation

in some phase of the satellite programme may be made in the Advisory Council.

**Second Russian Base**

It has now been confirmed that the **second Russian base,** Pionerskaya, situated about 900 miles inland from Mawson, the Australian Antarctic permanent base, is established. The Australian Expedition describes it as a "splendid achievement, coming as it does so soon after the establishment of Mirny". The French and American bases as well as the Australian are receiving regular met-reports from Pionerskaya. These countries have added their congratulations.

***Ob* at Wellington**

Recently the Soviet Antarctic research ship *Ob* paid a courtesy visit to Wellington, New Zealand. During the visit the ship was thrown open to the public, and Prof. V. G. Kort, Director of the Oceanographic Institute of the Soviet Academy of Sciences, delivered a paper on the research that the *Ob* was engaged in during the 5000-mile cruise in Antarctic waters that she had just completed (February 29 to April 8).

The *Ob* with her sister-ship the *Lena* (both specially built for polar research in Danish shipyards last year) were the base-establishing ships earlier in 1956 for Mirny base, on the Antarctic coast. Prof. Kort confirmed that Mirny was built on rock. "Naturally the landing was very difficult," he said, this was due to the very rapid *ablation* ("going down") of the ice-coast so that the expedition was obliged to unload direct on to the "worst type of ice-wall", 20 metres high. (Note: "ablation" causes a depression of the ice-shelf surface; hence stores, etc., would be liable to sink in and disappear. By the "worst" ice-wall is probably meant the highest found.)

A report of this lecture has reached DISCOVERY. It is of unusual interest so that, although some passages and terms are still ambiguous, it is worth giving an immediate account of it as illustration of the scope and style of Russian petrological research and the readiness with which their scientists are prepared to speak of "conclusions".

The main scientific researches to be conducted from the three Soviet bases proposed and from the research ships was summarised as follows: (1) the study of Antarctic atmospheric pressure as it affects the common separation of global weather; (2) the geological frontiers of the Antarctic continent; (3) the geological history of Antarctica; (4) the study of the ice-cap and in particular glaciological dynamics; (5) a special study of the geophysical peculiarities of Antarctica; and (6) the collection of physical and geological specimens in this region.

Research into all these fields will be carried out by ship-borne expeditions not only round the Antarctic coast but in the Pacific and elsewhere. Another approach is by means of continental traverses; these can be readily performed by air and less easily (though more usefully) at ground level. These continental explorations are planned for the period from December 1955 until April 1959. The research from the sea is already well in hand.

The Soviet expedition is relying on the mutual exchange of samples and information with the other countries participating in the Antarctic programme, and also on close study of the "very rich experience" of previous Antarctic expeditions. Since the *Ob*'s New Zealand visit, the Australians cable that problems of mining minerals in Antartica have been discussed between Russian and Australian polar experts, at Adelaide. At Adelaide University Russian scientists from the *Ob* were shown samples of gold and other minerals mined in Australia, for comparison with Antarctic specimens. "Both the Australians and the Russians reported benefit from the exchange of technical knowledge," say the Australians.

At this visit to the port, Russian scientists from the *Ob* met Sir Douglas Mawson, the veteran explorer, who was with Shackleton's *Endurance* expedition.

**Voyage of the *Ob***

When the construction of Mirny camp and station (the *Ob*'s first task) was virtually finished, by the end of February, the *Ob* set out on her first programme of oceanographic research.

During the voyage she covered 5200 miles and made 76 oceanographic stations. The most interesting section of the trip was along the eastern coastal regions of Antarctica between 91° and 162° E. In this region the *Ob* steamed 4000 out of the 5000 miles of her voyage, carried out 4603 miles of echo-sounding, and set up 57 of the 76 oceanographic stations. During this part of the voyage the *Ob* kept very close in to the ice-shelf, passing Knox Coast, Southern Coast and the so-called (?) "Outpost Land of Discovery" near the North Coast. The expedition visited some islands near the South Coast where only a few weeks before the ANARE party in *Kista Dan* had previously landed for the first time in history (area near 110° E off Wilkes land).

From March 13 to 18 the Russians made "a rather detailed research" off the "Outpost Land of Discovery" area. In particular echo-soundings along the ship's course yielded valuable material for the future study of the Antarctic shelf beyond 70° E. Already study of these readings clearly shows that there is a "fault" in this region of the Antarctic continental shelf. One line of soundings distinctly shows that on the sea-bottom there are two "walls" which are divided from each other by a big fault, trough, or *graben*. (By the "walls" is probably meant that the fault-scarps form something resembling walls.) The Director of the Geology department of the expedition thinks that these so-called "sea-walls", which have a tectonic basis, stretch parallel with the Ice-barrier throughout the Davis Sea. This can be seen also farther East up to Terre Adélie (135° E). The northernmost of these two "walls" coincides with the position of the extreme end of shelf-glaciers at those places where there has been maximum movement of these glaciers oceanwards.

The expedition's geological party made a systematic study of ocean-bottom deposits during the voyage. On this a total of fifty-three bottom samples were scooped up, and sixteen sediment cores were bored, the longest being 454 centimetres [a considerable feat]. From the analysis of the bottom-samples, the presence of rock shows a correlation with certain petrographical provinces belonging to coastal waters. This means that there have been two main provinces, one in the region of coast from (?) Cape Darnley up to the Helen Glacier, the other round the Shackleton Ice-shelf. Regarding ice movement, the geological studies suggest that there are petrographical provinces which belong more or less specifically to this coast and the North Coast.

The collection of rock deposits along the **Eastern Antarctic** coast has great significance for the study of Antarctica's continental geology, since this area is almost always and everywhere hidden under the ice-cap, and many geological samples are permanently inaccessible. By the movement of rock detritus from certain geological provinces it is also possible to deduce how the sea-ice moves and in what main direction.

The geologists found in studying the bottom cores from the continental shelf of the Southern Coast that the siting of the different geological structures is quite clear. In the area from the Banzare Coast up to William II Land, layers of gravel-pebble detritus and diatomic silt

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The British correspondents for the fifteen IGY sections are:

I Dr. R. L. Smith-Rose
II Sir Graham Sutton, F.R.S.
III Mr. J. M. Stagg
IV Mr. James Paton
V Dr. W. J. G. Beynon
VI Dr. M. A. Ellison
VII Mr. Thomas Gold
VIII Dr. R. v. d. R. Woolley, F.R.S.
IX Prof. G. Manley
X Dr. G. E. R. Deacon, F.R.S.
XI Prof. H. S. W. Massey
XII Dr. R. Stoneley, F.R.S.
XIII ——
XIV ——
XV Dr. D. C. Martin

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was observed in the cores. The irregularity in the changes of bottom sediment often discernible reveal important features of Antarctica's paleogeography during the Quaternary period.

The materials to be collected by the future geological expeditions will of course offer further interesting material, and this should enable a clear geological history of the Antarctic region to be drawn up.

Other contributory researches carried out during the voyage were the study of sedimentary material suspended in the sea-water (by means of a special "membrane ultra-filtration method") and the mapping of the paleogeographic sections across the "zone of divergence" in the Davis Sea, Knox Coast, Southern Coast, and Terre Adélie.

The preliminary conclusion may be made that the whole shelf in this latter area is a special zone of formation in Antarctic waters. During the Quaternary period the glacial region may have extended twenty miles farther out from the Antarctic continent than it now does. Deposits from the descending glaciers of those times are to be found on the (present) ocean-bottom at approximately the 1000-metre contour.

On its departure from New Zealand the expedition will complete the oceanographic cross-section through the Eastern Sea and so back via Australia to Mirny and thence home to Leningrad. The materials collected will be studied in greater detail in the laboratories of the Oceanographic Institute of the Soviet Academy of Sciences.

The lecture also dealt briefly with meteorological and aerological work carried out during the voyage, and with some of the findings made by Russian marine-biologists. The most interesting results were obtained by the latter from dredgings down to 4000 metres in very deep waters (perhaps off the Balleny Islands 600 miles north of Cape Adare which Prof. Kort mentioned specifically). Some new species of crustacea were noted in these deep-sea dredges. Much quantitative zoological work was done, as well as qualitative observation and description.

It was disclosed that *Ob*'s complement consisted of sixty-nine crew and fifty-three scientists.

Mr. George Lowe, the Everest climber from New Zealand and now a member of the British Trans-Antarctic Expedition, spent half an hour inspecting the *Ob* in Wellington while he was visiting there. There have been many conflicting Press reports on the subject but in his estimation the *Ob* was a little under 12,000 tons. She was at the time standing well up out of the water as she was at the end of her voyage. He was deeply impressed by the ship's five research laboratories and their equipment. The quarters were also extremely modern in design and comfort, and he noted that in the mess-rooms the tables were finished in Formica-type plastic with a chess-board as the surface pattern: "Very nice—if you like chess!" in Mr. Lowe's view. The Russians were clearly very proud of their ship.

### Soviet Scientists' Conclusions

Dr. R. J. Adie of Birmingham, the Antarctic petrologist, says that the preliminary conclusions of the Soviet scientists seem to confirm the opinions of some British geologists that in the past (and probably during the Quaternary) the ice-cap of East Antarctica extended much farther seaward than at present. It is generally agreed that the Antarctic ice-cap is now in a state of decadence, and in the early Quaternary there were minor fluctuations of climate and precipitation resulting in variations of advance and retreat of the ice-cap.

Earlier conclusions were based mainly upon the evidence provided by soundings, dredgings, moraines, perched erratics and topographic, structural, and tectonic features. In some areas, low-lying offshore islands (probably associated with both structural and tectonic features), which were formerly engulfed and buried by seaward-flowing ice, protected the margin of the ice-cap and fixed it in one position for long periods of time.

It seems likely that in the past the ice-cap was aground for a distance of twenty or more miles seaward of the present shoreline. With the amelioration of the climate the ice-edge began to melt and glacial detritus was deposited on the sea floor, thus contributing to a local build-up of the continental shelf.

The results of seismic surveys also show that the present ice-edge in some parts of the Antarctic coastline is supported by isolated rocky masses, and part of the inland ice is actually aground below sea-level.

The observations of previous expeditions show that in the past the level of the inland ice in South Victoria Land was about 2000–3000 feet above its present level, and the Ross Barrier was at least 850–900 feet higher than it is now. At the height of the glaciation the Ross Barrier probably extended 160–200 miles farther seaward. Between 1841–2 and 1907–9 the Barrier is believed to have retreated some twenty miles.

Observations in south-western Graham Land (West Antarctica) reveal that deglaciation has been particularly active and there has been a considerable recession of the ice-shelves. Islands, rising to a hundred or more feet a.s.l. and still retaining their primitive ice-caps, which were formerly submerged beneath the ice, are now well exposed. Some of these are separated by at least 30–40 miles from the nearest ice-shelves. It is believed they served as pegs to hold the ice-edge in position. It is known that between 1940 and 1949 the ice of the northern and western limbs of King George VI Sound and the Wordie Ice Shelf has receded some twenty-five miles.

Clearly, along various parts of the Antarctic coast there has been differential recession of the ice-cap, due primarily to the phenomena mentioned earlier.

The conclusions of the Russians about the previous extent of the Antarctic ice-cap are not altogether original although the means which they have used to ascertain their facts has never previously been adopted on so large a scale in Antarctic research. In 1914 Priestley and Edgeworth David published a monumental volume on this very subject. The research of other expeditions has led to similar conclusions, though a great deal of this information has not yet been published.

### Site for Japanese Base?

In March, after completing her part in the establishing of the U.S. advance bases in Antarctica, the Americans' leading ice-breaker *Glacier* sailed independently on a westerly circuit of the Antarctic coast, from the Ross Sea as far as the mouth of the Weddell Sea.

It was a rapid voyage, 5000 miles in only three weeks. Apart from a few reconnaissance landings the ship stood well off-shore most of the time. An attempt was made to close the Prince Harald Coast to find a site for the Japanese base, but because of ice conditions and other factors the ship never made contact with the coast.

### Nigeria Makes its Plans

A programme of IGY research has been drawn up for Nigeria. The whole of the research facilities and personnel at the Physics department, University College, Ibadan, will be concentrated on this work, and the college has set aside several thousand pounds for the IGY. The Nigerian College of Arts, Science, and Technology, which has branches at Zaria (Northern Nigeria) and Enugu (Eastern Provinces) as well as Ibadan, will also participate.

With approval from the Central Government, various government departments—such as those for Meteorology, Surveying, Fisheries, and Posts and Telegraphs—are expected to contribute. Some government funds may be available to the colleges to augment their own resources.

Nigeria is roughly square, 700 miles across, bounded by the north-parallels 4° and 14°, and by the 3rd and 13th meridians. From a geophysical point of view it is of unusual interest because the **magnetic equator** almost bisects the country. Nigeria is therefore one of the few lands where relatively good communications exist over 500 miles or so along and across the magnetic equator. Nigeria's University College, is situated at Ibadan at the SW corner of the country (7°26′ N, 3°53′ E) at about 700 feet above sea-level. Geologically, Ibadan lies on the fringes of the Pre-

Cambrian Basement Complex, and the highly metamorphosed rocks of this complex outcrop in many places on the College site.

The College's Physics staff will be fully extended in doing three main branches of IGY research, on geomagnetism (III), on the ionosphere (V), and on atmospherics under Meteorology (II). The British National IGY Committee has encouraged the scheme by arranging to supply equipment.

II. The Radio Research Station, Slough, is proposing to send to Ibadan, on loan, a lightning-stroke counter, a lightning-direction finder, and an atmospheric-noise analyser. With this apparatus, **equatorial atmospherics** can be thoroughly analysed.

III. **Magnetic variations** will be measured at Ibadan. A set of La Cour variometers for normal recording has been installed and regular observations are already being made. Absolute values are determined with a CIW earth-inductor magnetometer loaned through the Carnegie Institution of Washington. Other types of magnetic observations will be made as experience with the normal variometers suggests. The Ibadan variometers are on loan from the Danske Meteorologisk Institut, Kobenhavn; but a second set is on order and is expected in time for a second station to be operating for the IGY. Zaria, 1°22′ N of the magnetic equator would be the most convenient spot for this, but alternative

FIG. 1. An underwater explosive charge in the seaward approaches to the Gambia River. (*A British Petroleum Co. photograph.*)

FIG. 2. Aerial photograph taken at 77° 57′S, 37° 16′W, showing M.V. *Theron* at the ice edge, which eventually broke away.

(*By courtesy of the Trans-Antarctic Expedition.*)

sites are possible. The second station might, for example, be operated from a point actually on the magnetic equator, or 5 to 6 degrees South of it (which would then be about half-way between magnetic and geomagnetic equators).

A programme of field observations is also planned. A set of three QHM- and one BMZ-magnetometer are on order. Apart from using these in controlling base-line values at the variometers, it is hoped to occupy a series of sites for periods of a month or so each, at which absolute values can be determined, and from which eye observations of, say, H and Z might be made at hourly intervals. These stations would usefully be plotted along the range of magnetic latitudes from 4 to 6 degrees North.

V. Four types of ionospheric work will be carried on by the College's Physics department.

The department has on loan from the Radio Research Board an automatic ionospheric recorder, and regular **vertical-incidence-soundings** have been taken for some years. These will be continued and extended during the IGY.

Manually operated equipment for measuring **ionospheric absorption** at **vertical-incidence** has been in operation for some time and these readings will also be continued and extended. (This equipment is likewise on loan from the Radio Research Board.)

Equipment for the study of **ionospheric winds** is at present under construction. The method used will be that of the three-spaced receivers.

Equipment for the recording of **cosmic noise** on a frequency in the neighbourhood of 18 megacycles is planned. Construction should begin soon.

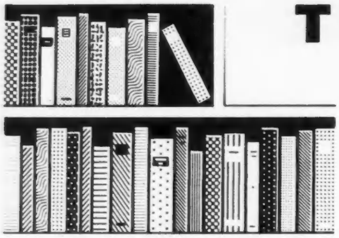
### Other Geophysical News

Recently the D'Arcy Exploration Company was granted a concession by the Gambia Protectorate to make a **geophysical survey beneath the bed of the River Gambia** which runs from French West African territory into the British Protectorate and thence to the Atlantic seaboard at Bathurst, the capital, where the Gambia is $2\frac{1}{2}$ miles across at the mouth. The river widens rapidly inland from the estuary, reaching a width of $7\frac{1}{2}$ miles at one point before narrowing again upstream. About 250 miles of the Gambia's course was surveyed by means of seismic soundings carried out from a specially converted motor-vessel, the 370-ton *Sonic*, which once belonged to the U.S. Navy.

The purpose of this survey was to see if this might prove a likely area for oil-prospecting. Nevertheless the method used and the geophysical exploration made has an immediate bearing on the non-commercial search for more knowledge and understanding of the earth and its crust.

The research method used by the *Sonic* is known as the Seismic Reflector technique. In principle it is similar to "Asdic" echo-sounding. While "Asdic" records the reflection of energy from the sea *bed*, this technique obtains echoes from the geological strata *below* the bed-rock. The survey trailed astern a length of plastic cable some 2700 feet long. This is known as a streamer and provides a water-tight housing for the recording instruments, including the geophones. The ship steers a given course at a constant speed, while an explosive charge is passed out astern every two minutes on a line trailing it at roughly a depth of 6 feet (below the surface). When it reaches the middle point of the streamer it is detonated and the impulses set up are reflected on to the geophones and passed to a recording camera as electrical pulses. This produces the picture of the geological shape below the bed.

The *Sonic* made a geophysical survey of a wide area centred on 250 miles of the Gambia's bed, in only ten days. Whereas part of the river is as much as $7\frac{1}{2}$ miles wide, another section to be surveyed was so closely flanked by mangroves that it took the ship four hours to be warped round for the return journey.



# THE BOOKSHELF

**The Work of WHO, 1955:** Annual Report of the Director-General to the World Health Assembly and the United Nations.

*(Official Records of the World Health Organisation, No. 67, xii+241 pp., illustrated by 16 pages of photographs. Available also in French and Spanish editions, 10s., $2.00., Sw. fr. 6.)*

Ten years ago, on July 22, 1946, China and Great Britain were the first countries to become parties to the constitution of the World Health Organisation. Canada, Iran, New Zealand, and Syria had followed suit by the end of the year. Now, eighty-five countries are members of an organisation whose staff comes from over fifty nations. Gleaned from annexes to this annual report of WHO—embryonic Ministry of Health in the world government of the future—these facts help to put the doings on our planet into global perspective.

The Director-General's introduction to this lengthy document, with its fifty photographs of work in the field, notes substantial results in the fight against communicable diseases, in the strengthening of national health services, and in raising standards in the training of health personnel.

Malaria, a scourge to most of the British Commonwealth for all that the "tertian ague" has left these islands, has always been a first concern of WHO. Insecticides have been the most-used preventative. However, it is now recognised that, like other insects, the mosquito carrier can acquire resistance to their effect. Accordingly the plan henceforth aims at complete eradication of the disease, before immune strains can develop. In some countries, such as Africa, pilot projects are needed before such a programme can be worked out.

In the field of tuberculosis new developments in chemotherapy have produced changes of emphasis. Countries whose economy does not favour expensive hospitalisation programmes with specialist staffs, can be helped by factual surveys of the extent and nature of the problem. The control of tuberculosis may then be possible in the framework of a public health programme.

One cannot begin to summarise the field of a year's work by WHO, from the development of public health services, and planning in environmental sanitation, to the publication of Volume II of the *Pharmacopoea Internationalis*, and study of the project at Calioub where health, education, agriculture and other social factors are combined into one pattern of community service. (Project No.: Egypt 5.) Some 370 of these projects, often co-ordinated with other UN. or Specialised Agency, work are listed in detail.

Their study reminds us that we live in a sick world. It is also disturbing, but may be healthy, to compare the £3 million annual budget of WHO with, say, the £900 million per year which we in Britain spend on tobacco.

GEOFFREY BELL

**The Life of Ludwig Mond**

By J. M. Cohen *(London, 1956, Methuen, 296+xvi pp., 22s. 6d.)*

It is a matter for wonder that although Ludwig Mond died in 1909, his Life was not written until he had become almost a legendary figure. Even the name of his younger son, Alfred, whose Biography by Bolitho was published over twenty years ago, is well on the way to being forgotten except by those students of Management who vaguely recall the Melchett-Turner conferences as the foundation stone of joint consultation.

In these fustian and narrow-gutted times it is salutary to be reminded of the success stories of the hey-day of private enterprise. Mr. J. M. Cohen, making this his first incursion into biography, is to be congratulated on presenting a very human picture of one of the outstanding industrialists of his age—an industrialist not wholly immersed in his trade, but willing and able to appreciate the humanities as well as the human side of life.

To the industrial historian this biography is of interest, not only for the information it gives of the incunabula of such apparently modern concepts as the gas-turbine, but also because of the light it sheds on the first beginnings of a social conscience in management, a conscience which is by no means common even today.

To the industrial chemist the book is slightly disappointing. Mr. Cohen is understandably more interested in the impact of a Casselaner Jew on the industrial midlands at the end of the last century than in the industry itself. Thus we are left in many places wishing that the technical background had been more fully sketched in—more fully even than is done in the two dozen breathless pages of Technical Appendix.

Perhaps the most notable omission from this point of view is any detailed account of the appalling vicissitudes that beset the infant Brunner, Mond and Co. during the three years it took them to introduce the Ammonia-Soda process into Great Britain. One feels that Mr. Cohen might have given the subject more than a perfunctory nod of a page or so. Still, that is an epic in itself and one must hope that in due course, Mr. Cohen or another will be found to do justice to such an important chapter in the industrial history of Great Britain. For in those days there were giants on earth.

**Extrasensory Perception.** Ciba Foundation Symposium

Edited by G. E. Wolstenholme *(1956, Churchill, 240 pp., 27s. 6d.)*

The latest Ciba Foundation symposium discusses, in an atmosphere of friendly good humour and at a high scientific level, the emotionally charged subject of ESP. Often we find that, in a discussion of experiences that seem incompatible with the rational scientific view of the world, our permanent mental defences against the apparently irrational lead to a denial of evidence in an emotional and irrationally determined way: several of the scientists taking part in the symposium did indeed confess to a subconscious prejudice against belief in ESP. During criticism of the application of statistical methods to ESP, a suggestion was made that similar empirical data should be found (not involving ESP or any psychological effects) and submitted to a mathematical journal for evaluation as to chance probability.

The great need to find repeatable experiments in ESP was stressed by many speakers; it is interesting that the biological scientists, who are used to working with animals or human beings, seemed more willing to agree that such experiments as those of Dr. Soal and Mr. Shackleton are essentially repeatable, than were some of the psychical research workers. The scientists were also readier to agree that the success of sensitive subjects when freed from rigorous routine control was a natural event. On the other hand the psychical research workers, more familiar with the trickery revealed in past experiences and more subject to outside criticism of their own work, stressed the need for rigorous control. Perhaps the most suitable method is to start under informal conditions and to improve them gradually, until the most rigorously controlled experiments can be carried out with the full co-operation of the sensitive subject.

There were differences of opinion about whether ESP should be regarded as a nascent faculty, or one slowly being atrophied under the stresses of civilised life; and the need for more experiments with primitive people and animals was emphasised. Dr. Wassermann outlined an interesting theory (shortly to be published in full) of a morphogenetic field which would interact with a psi field and with matter following rules akin to quantum mechanics. Other topics dealt with

included the evidence from psychoanalysis, and the homing instinct of birds. A new definition of ESP was suggested: "extraordinary sensory perception". F. J. M. STRATTON

**Geography for Boys and Girls**

By F. N. S. Creek (*London, 1956, English Universities Press, 96 pp., 7s. 6d.*)

Geography, as taught at school, is sometimes rather a dull subject, remembered chiefly as a catalogue of countries and places, with their principal exports. This is a book for holiday reading, and it should appeal to young people who are interested in the planet on which we live and its physical features. Starting with an account of how the Earth is mapped, with lines of latitude and longitude and the construction of maps in general, the book goes on to describe how the physical features came about. The origins of mountains and valleys, the effects of rivers, volcanoes, and glaciers, are all dealt with. One chapter explains Weather and Climate and the effects of the Trade Winds and the Gulf Stream. The last chapter describes the main physical features of the British Isles, its mountain frameworks and the Five Great Coalfields. The forty-two diagrams, many in colour, are drawn in a clear and simple style. Some of the matter requires a little intelligent concentration, but subjects such as the variation of local time with longitude, and the results of heat zones and the Earth's rotation in generating winds, are explained very fully. The author has an easy conversational style and is fond of asking rhetorical questions. It is a pity that the chapter on maps says nothing about the problem of representing a three-dimensional sphere on a two-dimensional surface, and the consequent variation of scale in maps showing large areas of the globe. A glossary of terms would have been useful in an elementary book of this kind: for example the terms "Tropic of Cancer and Capricorn", which are referred to in the chapter on Weather, are nowhere clearly explained. The book, which is one of a series—the Junior Teach Yourself Books—should form a useful and interesting supplement to school teaching, but it is not intended to be a complete course in Physical Geography. ROGER NORTH

**Principles and Applications of Physics**

By Otto Blüh, in collaboration with Joseph Denison Elder (*Edinburgh, 1955, Oliver and Boyd, xiv+866 pp., 728 figs., 45s.*)

This unusual book is intended for students who want a comprehensive knowledge of modern physics—that is, physics in its modern guise—at an elementary level. It is not for laymen, who normally prefer to read only about the more spectacular aspects of physics, and it is not sufficiently advanced or mathematical in treatment for specialists. It might, however, prove useful as a "refresher" for any one-time student whose physics is rusty through lack of use, and it would be ideal for any such person now wishing to help to relieve the shortage of science teachers.

The authors make a special effort to place their subject in its relation to other branches of human activity by including as the final part of the book four chapters on the scope and importance of the physical sciences, including, among others, sections sub-titled "the history of physics", "bio-physics", "physics, metaphysics, and the humanities", "physics and a philosophy of life", "the training and profession of the physicist". Dr. Blüh admits in his preface that these chapters must unavoidably reflect his own opinions in spite of his attempt to be objective. On the whole the reviewer found them interesting, refreshing, and clear, although he is doubtful about the objectivity and value of the following sentences: "The most important function scientists can fulfil in modern society is not to advocate and propagate scientific working methods as panaceas for the world's ills, but to establish within their own ranks an exemplary association of free ethical agents. This may also be the only way to maintain scientific activity as a liberal bulwark in a world in which free human society is on the verge of disintegration and collapse."

Together with the ordinary matter of bread-and-butter physics (achromatic lenses, boiling-points, combination tones, etc.) we find references to superconductivity, the cavity magnetron, the photographic process, television transmission, homopolar binding, uranium hexafluoride, nuclear reactors, UNESCO, neopositivism, Bondi, Gold and Hoyle. There is little mathematical development but a profusion of attractive and very instructive diagrams. The book can be warmly recommended. G. O. JONES

**Concrete Roads: Design and Construction**

Department of Scientific and Industrial Research (*London, H.M.S.O., 1955, 404 pp., with numerous plates and figures.*)

This book is a collection of lectures, papers, and articles written by past and present members of the Road Research Laboratory staff. Like its companion, "Soil Mechanics for Road Engineers" (published by H.M.S.O. in 1952), it is intended as a reference book for practising road or airfield engineers, but much of the information will be of value to students and engineers concerned with the production and quality control of concrete.

Part I deals with concrete as a material. Starting with the physical properties of concrete and its constituents, the reader is given a comprehensive account of the factors affecting the strength and durability of hardened concrete. This section also includes the well-known method of mix design developed at the Road Research Laboratory. Site and laboratory control tests for concrete are fully described together with elementary statistical methods for interpreting results and controlling quality on the site.

Part II is devoted to design of the road structure including theoretical methods for calculating stresses in concrete road slabs. However, because of the complexity and variability of the soil on which road structure is laid, pavement design recommendations are made on the basis of experiment and experience rather than theory. An account of the design and construction of prestressed concrete roads is also included. Much of research on roads is conducted by examining defects in existing roads, and so it is not surprising that the book contains a full account of defects which have occurred.

Part III deals with plant and equipment used in producing concrete and laying concrete roads. The chapters describing performance tests on mixers and compacting machines are particularly informative. Investigations to isolate the factors affecting the riding quality of concrete roads are described but, probably because most of this book was written before 1954, no mention is made of modern developments in construction techniques now used so successfully on the Continent. L. S. BLAKE

**Introduction to Organic Chemistry**

By J. T. Stock and M. A. Fill (*London, University Tutorial Press, 1955, 249 pp., 7s. 6d.*)

The authors of this new G.C.E. advanced and scholarship-level booklet are respectively Vice-Principal and Senior Lecturer at the Norwood Technical College. Small-scale techniques developed at this college are used in many of the experiments described, because they have considerable value under modern conditions where materials and space are limited and the use of costly apparatus is out of the question. Presumably money is no more readily available for textbooks, and the authors no doubt had this in mind in producing this one. Unfortunately, although the book is clearly intended for class use, little more than a teaching outline is offered. Without the help of a teacher capable of enlivening the subject and adding more detail few pupils would realise that organic chemistry could be fun or be able to answer the questions given at the end of each chapter. The text is better when describing experiments than when dealing with theory. The book is commendably up to date in its mention of recent experimental methods, and can be recommended to instructors wishing to plan their own lessons. W. ASHWORTH

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L. S. BLAKE

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A. Fill (*Lon-
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ASHWORTH

# SCIENTIFIC FILMS

### "Forbidden Planet" (Cinemascope)

Man, having revolutionised his environment in a couple of centuries, has had to revolutionise his fairy stories. Their modern counterpart is science fiction—"S.F." to use the economy label of its practitioners. No longer does the bard of old tell his tale of wonders unimaginable; a new entity, compounded of big business, plus the technology of optics, electronics, and acoustics, its activity centred in California, U.S.A., puts our modern myths out among the nations. The science fiction film interprets tomorrow's world to the masses. Whether it does so responsibly or otherwise concerns those for whom science is *not* fiction.

The planet of the title is an Earth-type body, one of the system supposedly found about Altair, the "main sequence" star, $\alpha$ Aquilæ. And if we permit ourselves a knowing smile in the dark when told that our descendants' discovery of "hyper-drive" in the twenty-first century permitted travel at speeds greatly exceeding that of light, should we not recollect that radio and human flight were not so long ago also physical impossibilities, to those who knew? Even in our own school-days, was it done to split atoms?

Freed from the laws of physics of 1956, the CinemaScope-Eastman-Color space vehicle makes the journey, in something under a year, its purpose being to rescue a previous expedition which vanished without trace. The search-party does meet a survivor from the earlier expedition. In the intervening twenty years he has devoted his knowledge of philology to deciphering the historical records of the long-extinct and immensely advanced previous civilisation of Altair-4. This has enabled him to augment enormously his own scientific knowledge, and even construct an engaging robot—Robby—who sees to his physical needs and those of his daughter. She provides those diversions which mass entertainment requires, over and above what are furnished by an expedition to a planet sixteen light-years away.

Clearly, the story strains what our present-day conditioning teaches us to regard as credible; but if we care to let that pass, this screen play by Cecil Hume (based on a story by Irving Block and Allen Adler) puts a valid dramatic question. Is it proper for one man, knowledgeable beyond the limits of his human kin, to keep parts of that knowledge to himself, on the grounds that its use by the less well-endowed could be dangerous? The leader of the Earth-ship reminds us of an unwelcome truth (if our twentieth-century psychology is in touch with truth). "We are all part monsters in our subconscious," he declares, and adds, "so we have laws and religions".

The film naturally has that style of Hollywood sense-appeal, displeasing to the supercilious. But behind this is a healthy acceptance of the machine as part of the environment; for example, the space-ship crew calmly take their positions to be "de-atomised" into blurs of green light as they decelerate down through the "light barrier"! Most of the machines make pleasing sounds—credit to Electronic Tonalities by Louis and Bebe Barron. Even Robby the robot, entrusted with the synthesis of liquor by the space-ship's "earthy" cook, seems not beyond getting drunk. Fred McLeod Wilcox's direction is a happy contrast to that of most science fiction, where every mechanical operation calls for a sort of hysterical bravado and synthetic heroism. Machines, it is suggested here, are monsters only if men let them be so.

Those who prefer escape into a world of crime-thrillers and war stories may not take to "Forbidden Planet". The spiritually unenterprising may reject its unafraid jollity in the face of the Cosmos. ("The Lord sure makes some beautiful worlds!" says one of the crew on first sighting planet Altair-4.) But a film which encourages anticipation of the future with a lively interest—even hints that we today perhaps take our sex life a little too seriously—at least may discourage complacency on our twentieth-century Sol-3.

GEOFFREY BELL

### The H-Bomb

Made by R.H.R. Productions Ltd. for the Home Office. B. & W., Sd., 22 mins. Made in 35 mm. and available in 16 mm. on hire from the Central Film Libraries, and on sale from the Home Office.

Grimly and soberly this film shows the kind and the extent of damage that may be expected from a hydrogen bomb 500 times more powerful than the "nominal" atom bomb, the bomb dropped at Hiroshima. It does so without theatricals and without gloss, a tribute to the audiences who are expected to see it.

It was stressed at the Press Showing that this is a "training" film, yet apart from telling people to whitewash windows, build trenches, take cover, and preferably stay indoors, it gives no instruction in defence measures. Instructions are to be had, of course, in the civil defence Training Manual *Nuclear Weapons* (H.M.S.O. 2*s.* 6*d.*), but audiences are not necessarily to know this, and it is a pity that the very effective "punch" of the film is not followed up with some indication, if not about what people can do, at least about where and how they may obtain the information. Are any, and if so what, first-aid measures suitable for "flash" burns? What medical supplies might usefully be stored in a protected room? Is there any protection against radiation other than not going into the contaminated area? These and many other unanswered questions come to mind. The film arouses interest and also some serious thinking; but the audience is left with a sense of frustration.

It is understood that the film may possibly be televised, in which case an introductory and possibly also a final talk may make good the film's defects. If it is distributed generally to cinemas, it would surely be advisable to prepare a leaflet indicating where more information can be obtained and perhaps listing some practical defence measures.

What the film does do, extremely well, is to show that the effects from the detonation of an H-bomb, though grave, can to some extent be combated by intelligent forethought and intelligent action, at least at the outer areas of an explosion. A copy has been placed with NATO, and it has been seen by Commonwealth Relations Officers in this country. It is to be hoped, therefore, that the film will be shown to select audiences in all highly populated and vulnerable centres of the globe, with suitable instruction either verbally or in the form of leaflets, adapted to local conditions.

I. NICHOLSON

### One Man and His Job

B. & W., Sd., 18 min. (16 mm. prints can be hired from the Central Film Library; 16 and 35 mm. prints can be purchased from British Productivity Council.)

This film gives a very clear explanation of what motion study is and how research into it is undertaken. The jumbled pattern of hand movements a worker had to perform before his job had been planned is contrasted with the symmetrical, Paul-Klee-like pattern which results when tools and machine parts are placed conveniently. A film of this kind might well be used as part of a worker's training, or to persuade those who prefer to "muddle along" that new methods are more comfortable and satisfactory for them, as well as more productive in the factory.

### List of Films on Chemistry

By B. Chibnall. *Scientific Film Review* 1956, Vol. 2, No. 2.

This is the third list of chemical films which has been published. The first, prepared in 1948 by Nunn and Michaelis for the Scientific Film Association, and the second, compiled by the American Chemical Society for the U.S.A. in 1949, were both disappointing. Chibnall's comprehensive list, which is now available, is unfortunately not a very great improvement, although of course it contains most of the more recent films dealing with chemical subjects.

The fault of all chemical film catalogues is the paucity of truly chemical films, and inevitably a great deal of *paddenda* has to be included to make a worthwhile catalogue at all. Chibnall's list, as he admits himself, contains many border-line cases, so that no known film of likely use is omitted. Chemists are worse served by film

makers than any other scientific profession, partly because of the difficulty of filming chemical reactions, but also because the chemical industry has not yet appreciated the value of good teaching films. (Such films are readily available for the engineering and medical sciences.) On another page of the same issue, Freeland reiterates his frequent plea for better teaching films on chemical techniques; if they were available, they would prove of value for both, industry and universities alike.

The greatest value which the present catalogue could have, would be to draw renewed attention to the lamentable lack of good chemical films. If as a result of it, only one new, and really useful chemical film is produced, it will have served its purpose. All chemists and film makers, interested in the subject of chemistry films will want to congratulate Mr. Chibnall for his conscientious effort.

A. R. MICHAELIS

# FAR AND NEAR

### The Night Sky in August

*The Moon.*—New moon occurs on Aug. 6d 11h 25m. U.T., and full moon on Aug. 21d 12h 38m. The following conjunctions with the moon take place:

| August | | | |
|---|---|---|---|
| 3d 13h | Venus in conjunction with the moon | Venus | 3° S. |
| 7d 22h | Mercury .. | Mercury | 6° N. |
| 8d 03h | Jupiter .. | Jupiter | 6° N. |
| 13d 21h | Saturn .. | Saturn | 3° N. |
| 23d 21h | Mars .. | Mars | 12° S. |

*The Planets.—Mercury* is too close to the sun for observation during the month. *Venus* rises at 1h 35m at the beginning of August and 1h 15m at the middle and end of the month. It is a very bright object, stellar magnitude varying from −4·2 to −4·4 and the visible portion of its illuminated disk increasing from 0·297 to 0·492. During the month its distance from the earth varies between 44 and 65 million miles. Its brightness increases by 0·2 magnitude in spite of its increased distance from the earth because of the comparatively great increase in the visible portion of its illuminated disk. *Mars* rises at 21h 45m, 20h 50m, and 19h 50m on Aug. 1, 15, and 31 respectively. Its brightness increases considerably during the month, from magnitude −1·8 to −2·5; and the visible portion of its illuminated disk increases from 0·930 to 0·991. During this period its distance from the earth decreases from 43 to 35½ million miles and early in September it will approach the earth to within a distance of 35 million miles. In next month's issue something will be said about this close approach. *Jupiter* is too close to the sun for favourable observation during August. *Saturn* sets at 23h 25m, 22h 30m, and 21h 30m on August 1, 15, and 31 respectively, and can be observed for a few hours after sunset. Its distance from the earth varies from 896 to 942 million miles, and its stellar magnitude is about 0·7. It has a slow eastward movement in the constellation Libra, and attention has already been drawn to its close approach to the moon on August 13. The Perseid meteors—active during the greater part of August—attain a maximum about August 10–13: the radiant, which is the small area to which the paths of meteors traced backwards converge, is at R.A. 3h 8m, declination 58° N.

### International Astronautical Congress

The Seventh Annual Congress of the International Astronautical Federation will be held in Rome from September 17–22. This will be an important Congress on account of the proposed launching of the first artificial satellite of the earth.

### *Chemical Abstracts* Handsomely Housed

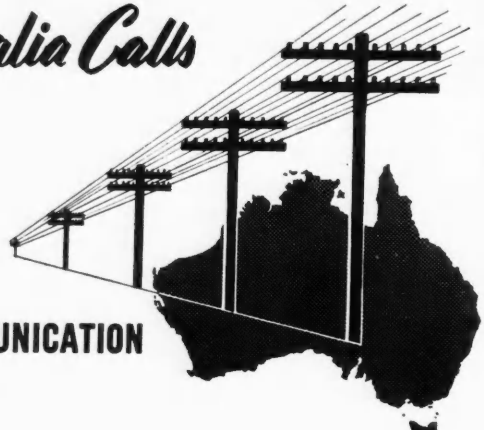
The new half-million-dollar home of *Chemical Abstracts*, "key to the world's chemical literature", was dedicated on June 8 on the campus of The Ohio State University at Columbus. The building is the first ever planned and erected exclusively for an abstracting and indexing service. The new building, the cost of which was shared by the American Chemical Society and the University, is designed to meet the special needs of Dr. Crane and his staff. The Chemical Abstracts Service is extending its research activities on methods of dealing with chemical literature, so there is a 1200-square-foot research laboratory and an office.

A novel device is a 4000-pound "merry-go-round" table, eight feet in diameter, around which as many as ten index editors can edit the 6 million cards which will be used to make up the publication's 19-volume Fifth Decennial Index. These workers must be able to use the indexed page proofs of *Chemical Abstracts* for ten years, and the roto-table makes this possible by providing ready access to the thousands of pages.

### *Calypso* to Explore Gulf of Guinea

The French oceanographic research vessel *Calypso* is bound for the Gulf of Guinea, off West Africa, where Captain Cousteau and his team of divers will explore the ocean bed and take photographs in depths of up to 30,000 feet. The *Calypso* will also carry out an under-water survey around the Portuguese island of São Thome.

# Australia Calls



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well qualified) under 30 on June 1 in the year of application with extension for regular service in H.M. Forces. London salary (including extra duty allowance where payable) £533 (at age 21), then according to age up to £708 at 26 or over, rising to £969. Somewhat lower outside London. A special increment of £25, within the scale, is granted after passing probation. Higher posts filled by promotion from Class II. Pay and conditions of service are under review.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health, and welfare of work-people and extend to all manufacturing industries and to certain other places, including docks, works of engineering construction, and building operations.

Candidates must normally be university graduates, preferably in Engineering or Natural Science (or comparable technical qualification, e.g. A.M.I. Mech.E.). Graduates in other subjects, including Arts, are eligible. Works or other practical experience an advantage. Candidates without degrees (or comparable technical qualifications) who have good general or technical qualifications, and have had considerable works or other practical experience (especially in responsible positions) will also be considered.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 280.

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COMMONWEALTH OF AUSTRALIA

## DIVISION OF FISHERIES AND OCEANOGRAPHY

The Commonwealth Scientific and Industrial Research Organisation invites applications for appointment to positions on the research staff of the Division of Fisheries and Oceanography which has its headquarters at Cronulla, Sydney, N.S.W.

(A) *PHYSICAL OCEANOGRAPHER*
*Appointment No. 320/103*

The appointee will be required to initiate and conduct research on Physical Oceanography, both as a fundamental study and also in relation to other studies in progress in the Division, particularly the well-established programmes on chemical and biological oceanography. The work is mainly concerned with the circulation of water masses in the Tasman and Coral Seas, the problem of energy sources and the structure of small-scale circulations along boundaries. Good facilities exist within the Organisation for the design and construction of modern physical apparatus for marine studies.

Dependent upon qualifications and experience, the appointee will be classified as a Principal Research Officer (£A2493–£A2933 p.a.) or as Senior Research Officer (£A1998–£A2273 p.a.). Qualifications are a University Honours degree in Science with Physics or Mathematics as major subjects, and considerable research experience in Physical Oceanography is essential.

(B) *BIOCHEMIST*

*Appointment No. 320/104*

The appointee will be required to carry out research on various biochemical aspects of the fertility and productivity of ocean waters, and to take part in studies on fish behaviour.

Dependent upon qualifications and experience, the appointee will be classified within the range of Research Officer (£A1263–£A1888 p.a.). He should have a University Honours degree in Science, with Biochemistry as a major subject, and some post-graduate research experience.

By arrangement with the successful candidates, the appointments would be considered either for an indefinite period or initially on a short-term basis of three years. In the case of an overseas appointment, first-class sea fares will be paid to Australia for the appointee and for his wife and family. At the end of a short-term appointment, return fares will be met by the Organisation. The appointment is conditional upon a satisfactory medical examination, and for an indefinite appointment he will be required to contribute to either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Applications, referring to Appointment No. 320/103 (Physical Oceanographer) or 320/104 (Biochemist) and stating full name, place, date and year of birth, marital state, nationality, present employment, particulars of qualifications and experience, and of war service, if any, and the names and addresses of at least two persons willing to act as referees if required, accompanied by copies of not more than four testimonials, should reach the undersigned not later than August 18, 1956.

(A. Shavitsky)

*Chief Scientific Liaison Officer*

Australian Scientific Liaison Office,
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ASSISTANTS (SCIENTIFIC): The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on January 1, 1956, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological sciences.
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Further particulars, for which you are advised to make early application, from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S.59/56.

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EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects and (*e*) Miscellaneous (including, e.g. Geology, Library and Technical Information Services).

*Age limits*: For Experimental Officers, at least 26 and under 31 on December 31, 1956; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1956. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1956 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

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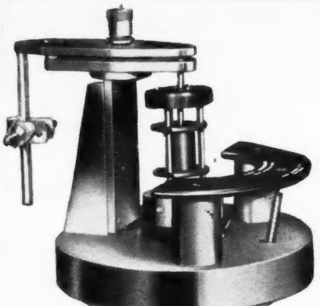

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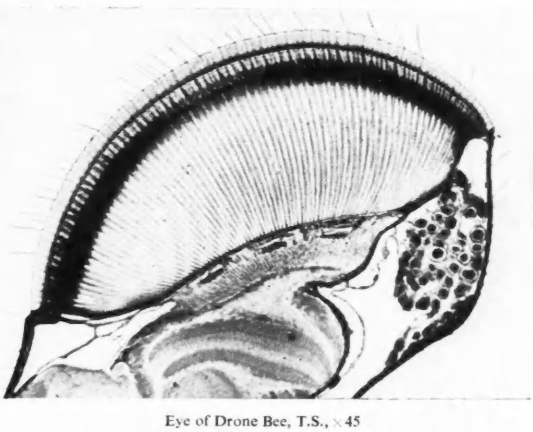

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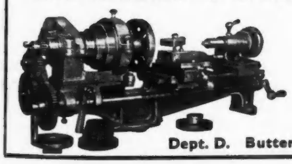

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